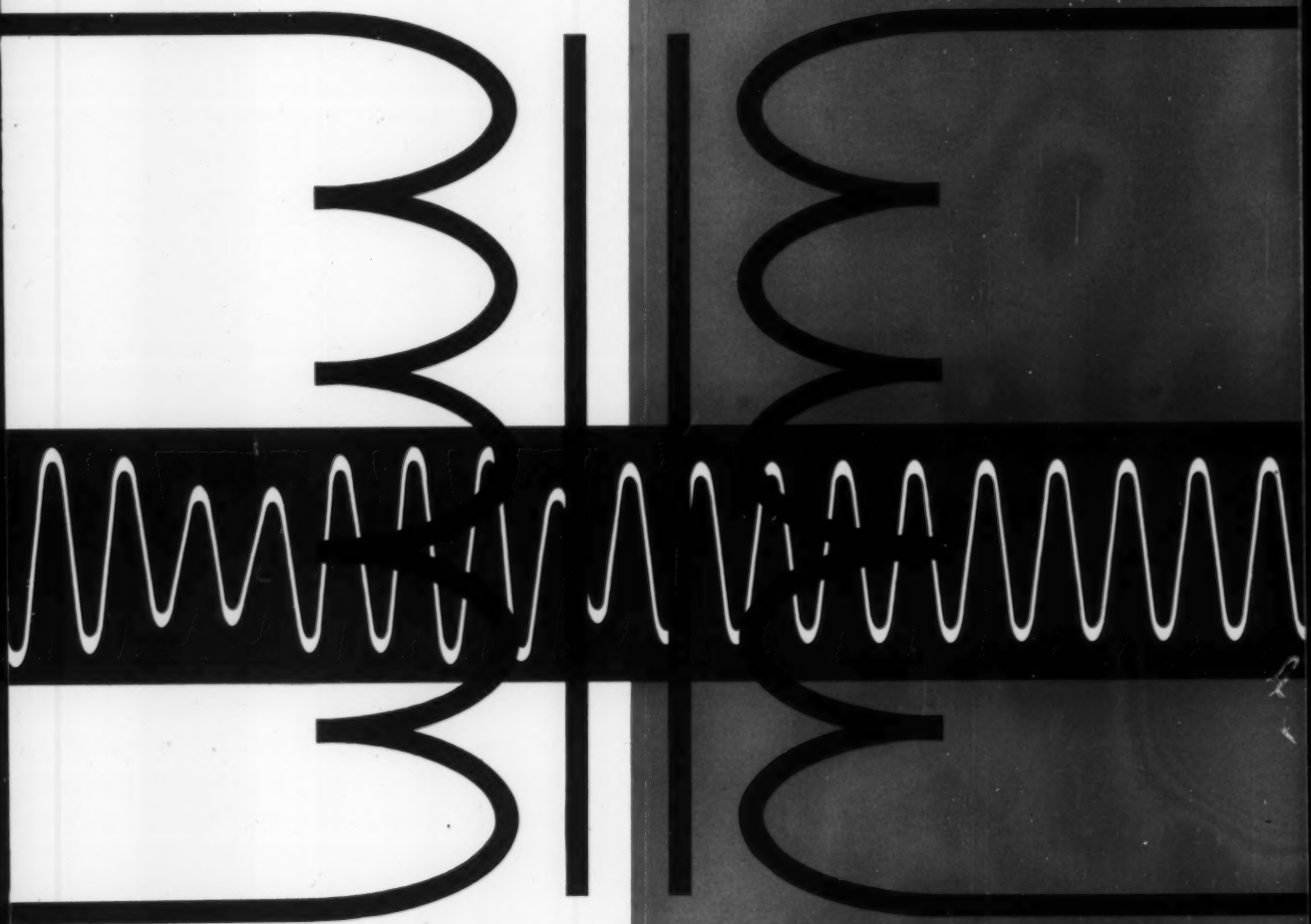
JUNE 13, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Voltage-Stabilizing Transformers

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RNSWORTH

Solve Bearing Space Limitation Problems

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EXTRA LIGHT

XLS Series Precision Bearings

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- **Have unusually large bores compared to outside diameter**
- **Provide utmost in accuracy, rigidity, and load capacity — (radial and thrust)**
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- **Allow greater freedom in design. In many cases these bearings provide the only solution where space is at a premium.**

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NORMA-HOFFMANN *Precision* **BEARINGS**

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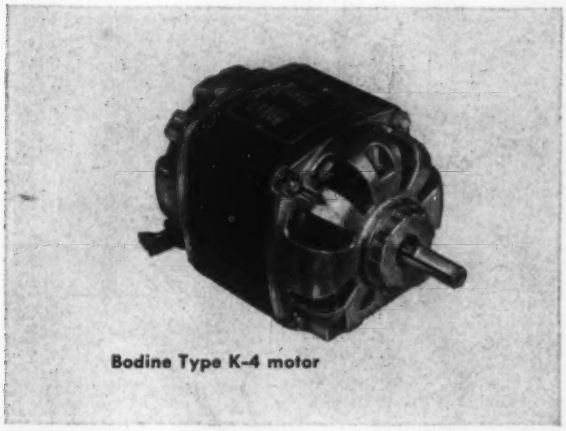
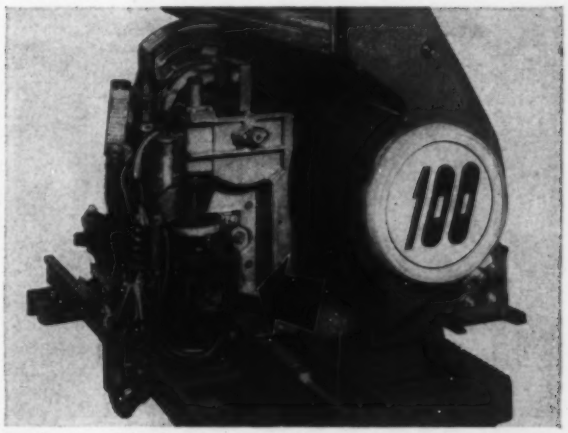
Seeburg Select-O-Matic uses BODINE MOTORS because..."THEY RUN QUIETLY, PROVIDE UNINTERRUPTED SERVICE"



Bodine Type K-4 motor

This small powerful Bodine induction motor drives the record changing mechanism and turntable of the Seeburg 100 and 200 Select-O-Matic phonographs. Compact size (height and width 2⅞"), constant speed, quiet operation, no radio interference, light weight and 5 mounting arrangements make the K-4 particularly well suited for use in office machines, movie projectors, communication equipment.



Inside view of the Seeburg record changing mechanism showing the vertically mounted Bodine Type KCI-42 motor. The 1/100 HP, 1600 rpm induction motor used in the Select-O-Matic positions the carriage, extracts the record from the magazine, plays it, and then replaces it. This sleeve bearing Bodine motor operates so quietly that no vibration is transmitted to the pickup head.

Here's a typical Bodine-motor-powered Seeburg automatic phonograph. It's coin operated and permits the selection of either side of 100 records. A dual credit system enables separate pay rates to apply to the standard records and the extended play records. Seeburg automatic phonographs have successfully withstood life tests of over one million selections.

Mr. M. W. Kenney, Director of Engineering, J. P. Seeburg, a Division of Fort Pitt Industries, Inc., tells why his organization uses Bodine Motors . . .

"The Select-O-Matic mechanism requires a motor that is quiet in operation and free from vibration; it must have high starting torque, fast reversal characteristics, uniform speed-versus-voltage, and very low stray magnetic field. In addition, the motor must give many years of uninterrupted service in the field. Bodine motors have satisfied all of these requirements for many years."

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June 13, 1957
Volume 29—No. 12

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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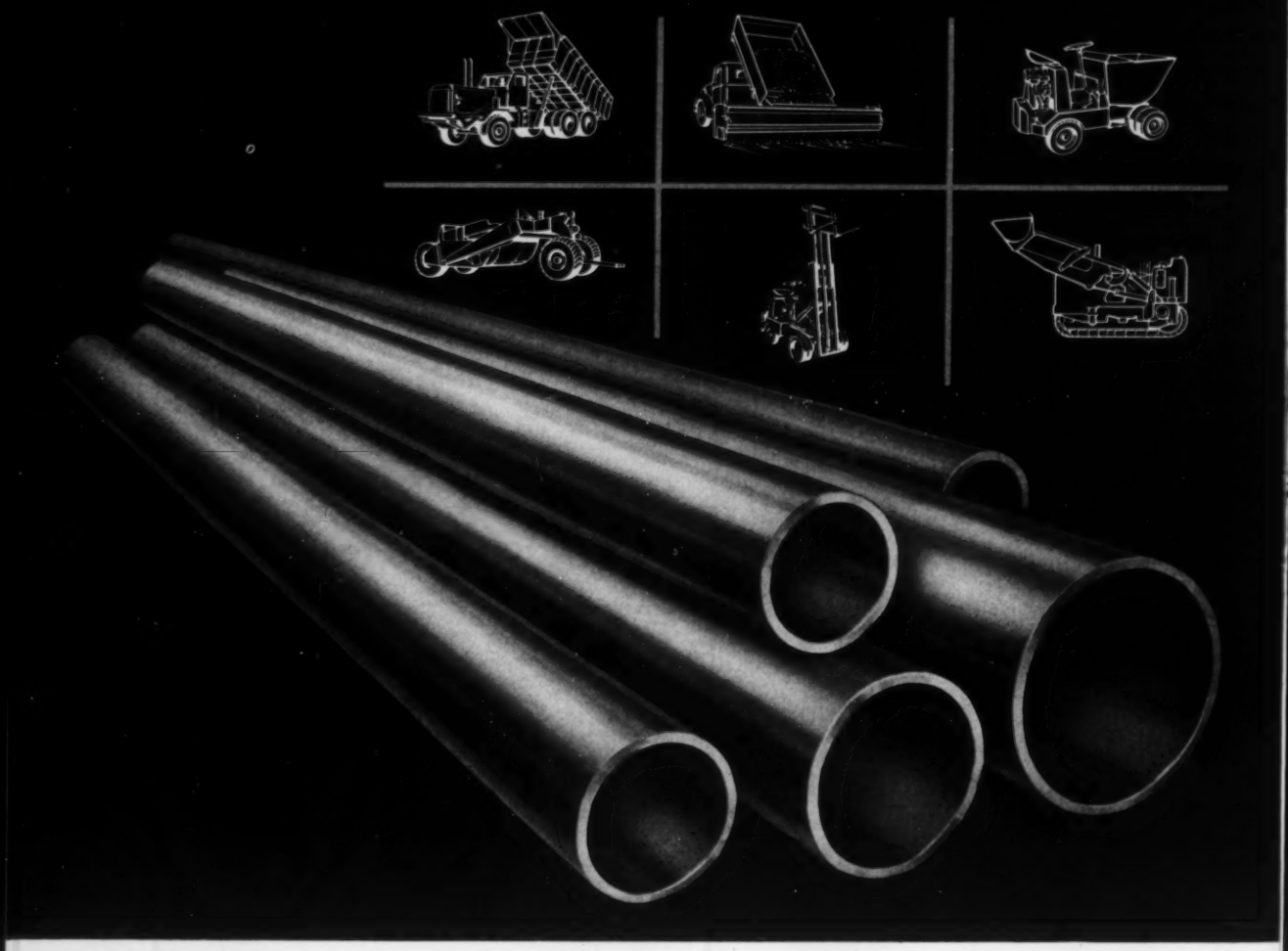
Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.



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Engineering News Roundup

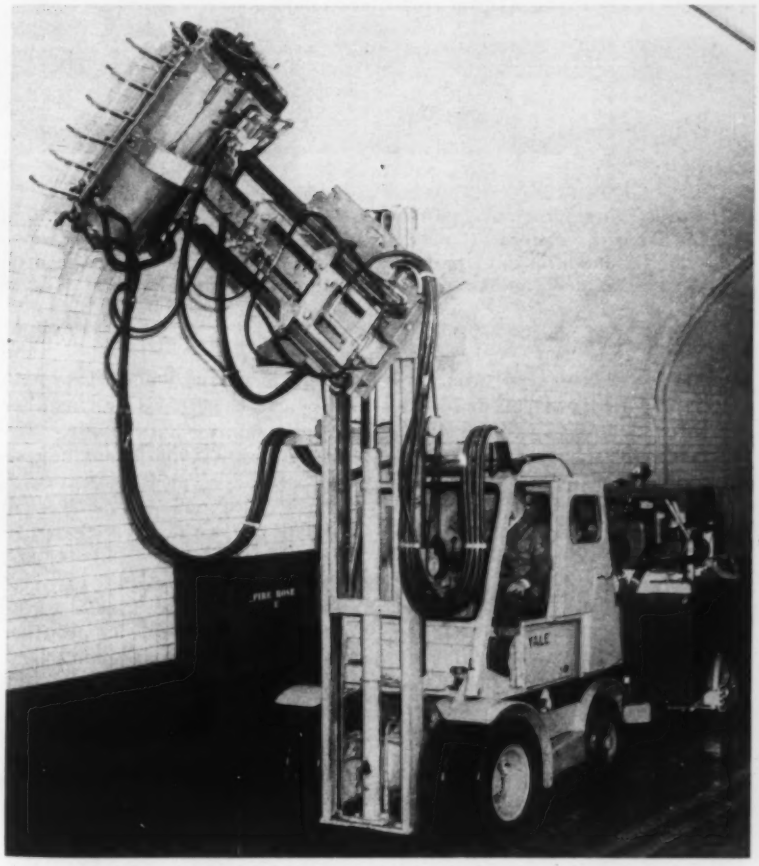
Engineers Urged to Give Grassroots Help to Educators

Every Thousand Students Have Only 1 to 3 Faculty Advisers

NEW YORK, N. Y. — Engineers should help educators in certain counseling activities as a matter of current necessity, according to Henry F. Dever, retiring president of the Scientific Apparatus Makers Association, and president of Brown Instruments Div., Minneapolis Honeywell Regulator Co.

Mr. Dever cited a recent study of the nation's scientific educational resources. It showed that current counselor-to-student ratios in high schools range from a low of 1 per 1000 students to a high of 3 per 1000. Only nine per cent of these counselors have a science background, themselves, and are therefore hard pressed to give effective counsel to potential engineers.

To improve and extend counseling in science, Mr. Dever proposes a task force of neighborhood "scientific advisory groups" staffed by the 250,000 engineers and scientists in the nation's 275 professional societies. The groups would originate programs designed to stimulate the interest of U.S. youth in science.



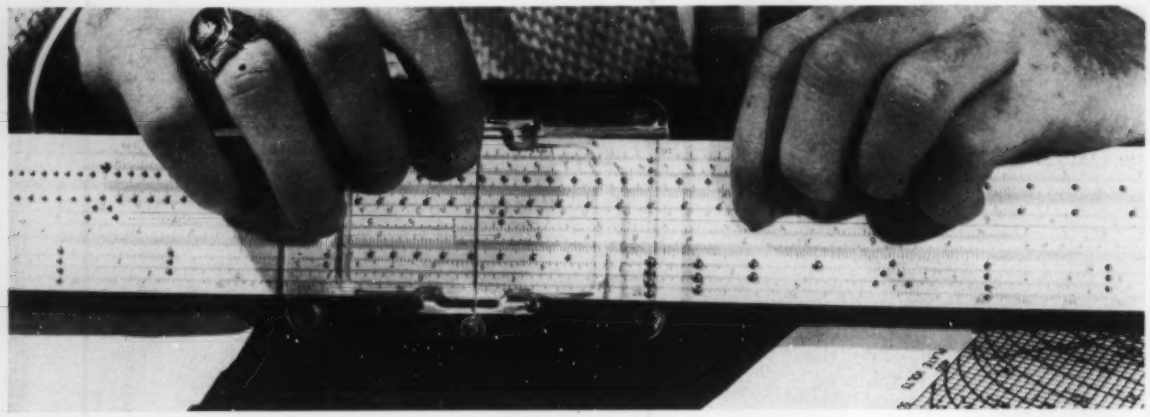
CLEANING IS A ONE-MAN JOB with this new mechanical scrubber now used in the Bankhead Tunnel, Mobile, Ala. The novel washing machine was designed and built by the Ross and White Co. under the direction of Palmer and Baker Engineering Co. As it moves through the tunnel at 1-ft per second, it performs detergent application, scrubbing and rinsing, continuously following the tunnel surfaces. It carries a high-speed, rotating nylon brush with spray components mounted and manipulated on a special boom of a conventional lift truck. The truck pulls a trailer which carries 650 gal of water, 80 gal of detergent and a 25-hp motor to drive pumps for the fluids and to move the scrubbing head hydraulically. Controls to maneuver the vehicle and to change scrubber positions are within easy reach of the operator. The truck expedites tunnel maintenance, but, of course, it's the kind of work that's never done.

Basic Aircraft Engine Can Be Made Turboshaft Or Turboprop

Powerplant Will Be Navy's First Convertible Unit

WASHINGTON, D.C.—Virtually two gas-turbine engines in one—both a turboshaft and turboprop powerplant—for use in helicopters, transports, and other support aircraft will be developed by General Electric Co. for the U.S. Navy. This "convertible" of gas-turbine engines will have a basic power section to which individual units can be added to make it either a turboprop or a turboshaft engine.

To be known as the T64, the new engine will be in the 2600-hp class. As a turboprop, the engine will be



SLIDE RULE FOR THE BLIND has raised-head brads at the principal graduations on a regular 20-in. Log Log Duplex Decitrig instrument made by the Keuffel & Esser Co. The modification was made by A. W. Keuffel, K & E vice president, and Brother C. Albert, instructor in electrical engineering at Manhattan College, for John Courtney, blind engineering student at the same school. Speed and accuracy with the knobby calculator have impressed its originators. Claimed average error is one-half of one per cent.

able to power advanced propeller-driven and short-takeoff-and-landing aircraft. As a turboshaft, it will be able to power helicopters and convertiplanes. Power-to-weight ratio will be more than 3 to 1 and specific fuel consumption will rival that of the latest piston engines.

Turboshaft and turboprop versions of the T64 will be designed for flexibility of installation. Both will have a three-point suspension arrangement and will operate with their axes horizontal, vertical, or at any intermediate angle. The T64 will have advanced engine control needing minimum attention.

Basic power unit of the T64 will be equipped with a remote reduction gear, helicopter controls, and torque meter to become a turboshaft engine. It becomes a turboprop by the addition of a propeller brake and an interchangeable bolt-on control package.

PUTTING DITCHES BACK IN SHAPE is the job performed by this tractor attachment called Lincol, made by Barford Agricultural Ltd., England. Driven from the tractor's power take-off, a roller chain can be adjusted to the shape of the ditch and can dig to a maximum depth of 3½ ft.

New Centrifuge Will Spin Truth About Missile Components

LOS ANGELES, CALIF.—An ultra-precision centrifuge for subjecting critical inertial-type missile guidance-system components to simulated operational acceleration forces will be developed by Genisco Inc.

According to the company, constancy of the new machine is about two orders of magnitude better than any centrifuge machine previously attempted. Full range of the machine, designated as the Genisco Model G460 Precision Centrifuge, will be 0.025 to 12 g with a precision payload, and up to 25 g with a nonprecision payload. A 300-pound test object can be accommodated.

The extreme accuracies of the centrifuge necessitated the use of new design techniques and mate-

Front Cover

Unlike most transformers, the unit pictured by artist George Farnsworth on the front cover is not primarily used to change voltage. Its main function is to smooth out fluctuations to produce a steady voltage output. Article on the subject by David E. Musgrave starts on Page 124.

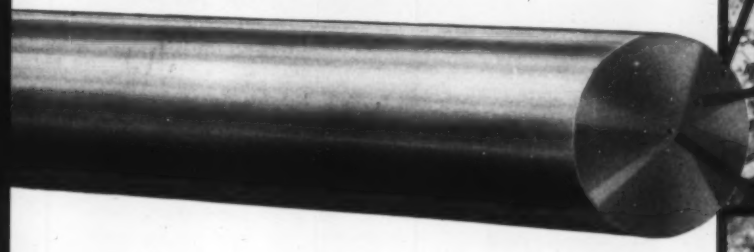
La Salle fatigue-proof STEEL BARS

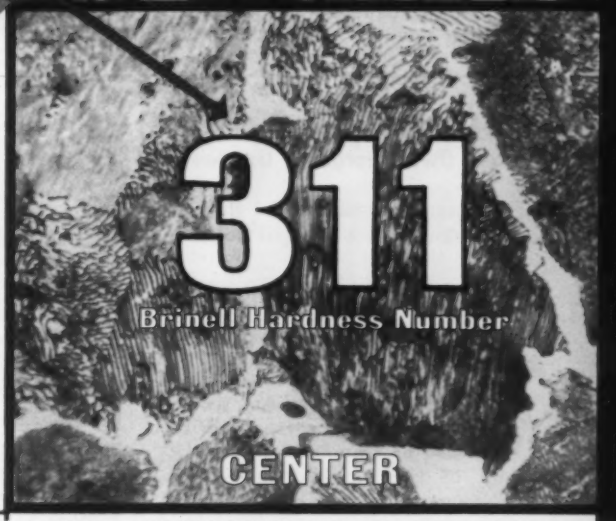
MADE BY e.t.d. PROCESS
Elevated Temperature Drawing

HAVE A UNIQUE COMBINATION OF

uniform properties

HIGH STRENGTH, MACHINABILITY, RESISTANCE TO WEAR AND FATIGUE, DIMENSIONAL STABILITY





The microscope shows the uniformity of FATIGUE-PROOF. Its uniformly pearlitic structure parallels its uniformity of properties from the surface to the center of the bar.

FATIGUE-PROOF strength and hardness are developed by "e.t.d." (Elevated Temperature Drawing). Unlike quenching and tempering, its effect is the same from surface to the center of the bar. It works a large bar as uniformly as it does a small bar.

There is no mass effect.

The microscope proves it. Surface, center, or mid-radius, FATIGUE-PROOF is pearlitic. There are no mixtures of bainite, martensite, and pearlite. FATIGUE-PROOF is uniform bar to bar, size to size, and lot to lot.

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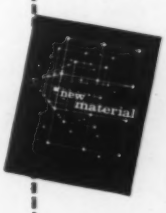

La Salle STEEL CO.

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Manufacturers of America's Most Complete Line of Quality Cold-Finished Steels Bars

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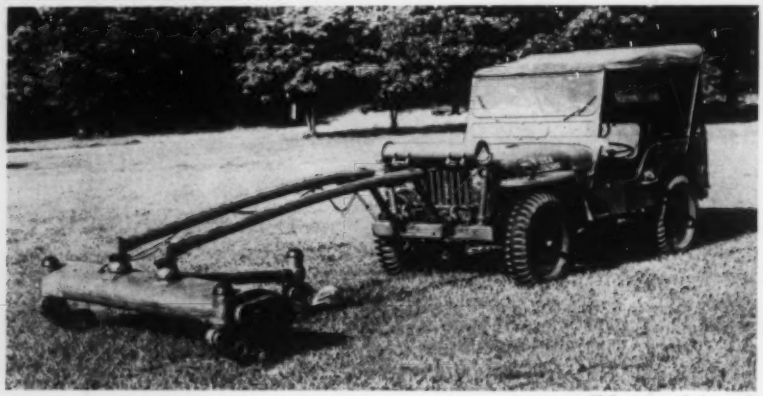
rials. These include temperature and strain compensation to maintain the critical radius tolerance, a fused quartz static radius measuring device, a comparator micrometer for measuring the radius under dynamic conditions and special rotor bearings under fluid pressure to maintain extremely close concentricity. A special 36 in. diameter differential synchronous motor was developed by Genisco engineers for precision wide-range speed control.



U.S. Army photograph

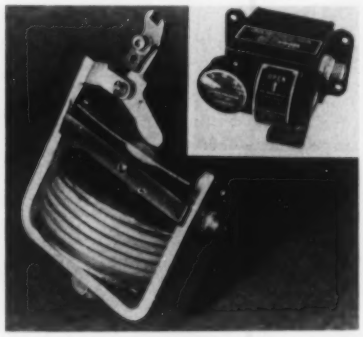
FASTER, SAFER SEARCH of buried land mines is the mission of this jeep-mounted detector recently developed by the Army Engineer Research and Development Laboratories. Brake actuator automatically stops the vehicle when the search coil passes over a mine. At the same time, lights on the jeep dashboard change from green to red and the driver is warned audibly through earphones. The search coil, immersion-protected, rides 3 ft above ground in a glass fiber carriage supported by skid-caster wheels. Detector and carriage assembly weigh 700 lb. They sweep a path 6 ft wide and can be moved sideways when jeep is stopped. Maximum safe speed for mine detecting, about 10 mph, depends on how far the jeep will skid when braked.

Jet-Liner Passengers To Have Their Own Emergency Oxygen

Automatic System Will Supply Mask And Gas Also to Tots

NEW YORK, N. Y. — Emergency oxygen will be supplied automatically to passengers in new 600-mph jet airliners if cabin pressure drops below a preset safe level.

Under normal operating conditions, emergency oxygen masks are concealed by trap doors in the bottom of the hatrack above each passenger's seat. If pressurization fails, a pressure-sensitive aneroid activates the entire oxygen system, automatically opening the trap doors and dropping the oxygen masks. The passenger has only to grasp the mask and place it on his face. An extra mask is provided at each pair of seats for infants or small children.



Trigger mechanism of new emergency oxygen system for passengers in jet airliners is activated by expansion of an aneroid and deflection of a leaf spring. Complete valve assembly appears in inset.

The mask has been specially designed of soft rubber to fit comfortably and correctly. It is sym-

Topics

Four-speed close-ratio transmission designed for sports cars is now offered as optional equipment on the Corvette. The new transmission's four forward speeds are synchronized to provide a swift and smooth response, according to a Chevrolet spokesman, and the close-ratio gears also permit easy down-shift to make maximum use of the engine for braking.

• • •

Altitude record for single-stage boosted rockets was set recently by a Navy Aerobee-Hi rocket that reached an altitude between 180 and 200 miles. The previous record for such missiles was 164 miles.

• • •

Two whole automobile bodies, with chassis, are compressed into a bundle the size of a four-drawer filing cabinet by "The Big Squeeze," a new 300,000-lb scrap metal baling press. The press is 18 ft long, 7½ ft wide and 5 ft deep.

• • •

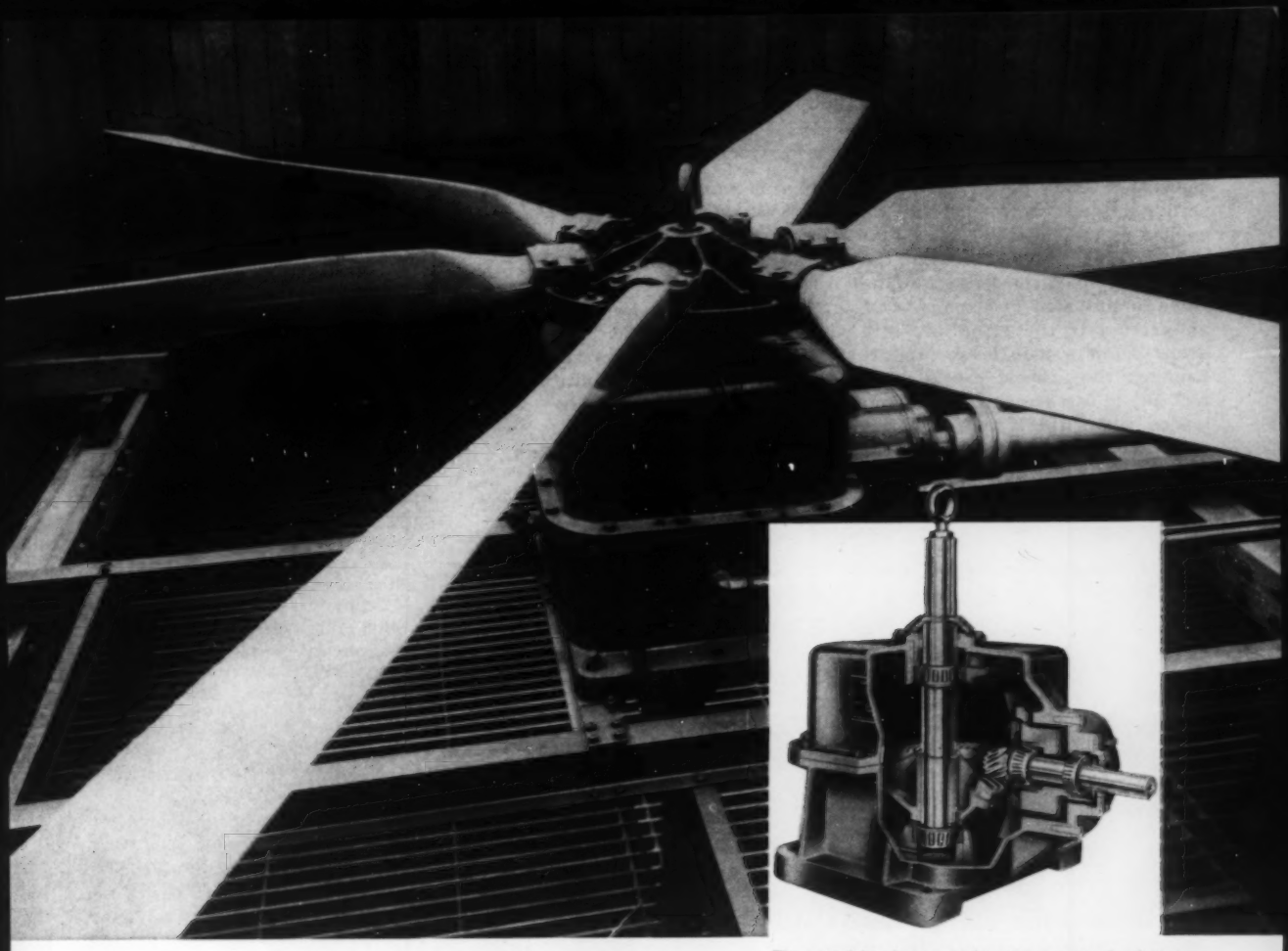
Remote registration at the motor entrance to a Texas hotel is made possible by an RCA closed-circuit television system. Three cameras, projecting pictures of the room clerk, the guest, and the guest's automobile, are used. A two-way intercom system is provided, and a pneumatic tube system is used to transfer registration cards, keys, bills and payments.

• • •

For the birds: a stainless steel nursery. A very practical Fort Wayne, Ind., bird chose tiny strands of stainless steel wire for nest-building material. The wire came from stock supplied by Allegheny Ludlum to Fort Wayne Metals Inc., who make fine filters for automotive and aircraft applications and special high-pressure cables.

• • •

Liquid-cooled automobile brake, developed by Raybestos-Manhattan Inc., is based on the principle of removing heat from the brake as fast as it is generated during stopping. The brake shoe is lined with copper. Water is supplied through a tube from the radiator cooling system. Tests indicate the need for considerably less pedal pressure than conventional brakes and life of about 100,000 miles.



This spiral bevel gear combination permits the flexibility required to meet rugged 24-hour service while providing an economical, self-contained unit which requires practically no maintenance.

How to obtain help when you design bevel gear assemblies

The men who designed the gear reducer for the cooling tower fan shown above were assisted in many ways by Gleason engineers.

Cooling tower fan operation is generally recognized to be one of the most severe tests to which a gear reducer can be subjected. These towers demand a gear system that can operate twenty-four hours a day, three hundred and sixty-five days a year if necessary.

The gear reducer is subject to heavy loads and lies in the path of moist, corrosive air streams.

The gear drives for these cooling tower fans are subject to heavy loads and lie directly in path of moist, corrosive air streams.

Here is what the customer and Gleason engineers developed.

A spiral bevel drive of 19 x 76 combination and 2.5 DP. With spiral bevel gears the tooth bearing is localized which assures smooth and quiet operation and permits some mounting deflections without concentrating the load dangerously near either end of the tooth.

The use of this gear design also allowed the flexibility required to fit the fan unit into the over-all design of the tower and to produce an economical, self-contained unit which requires little or no maintenance.

Next, our engineers produced and tested prototypes of the design which the customer in turn tested in the final product.

Our engineers can also help you select proper mountings for such gear assemblies and advise you on such details as lubrication.

If you would like to take advantage of this service, write us the next time you have a problem involving bevel or hypoid gear systems. Furnish data covering type of application, loads and speeds and prints of the mountings. We would be pleased to assist you in the selection of your gears.

Meanwhile, you may find these Gleason Technical Handbooks helpful in your work:

"20° Straight Bevel Gear System"
"Spiral Bevel Gear System"
"ZEROL Bevel Gear System"

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

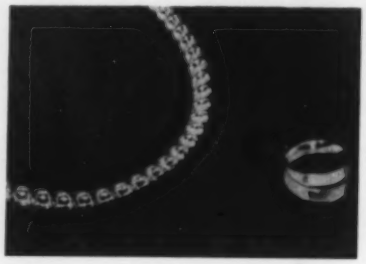
1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Circle 408 on page 19

metrical in shape so the passenger need not study how it should be applied to the face.

A trigger valve operates the emergency oxygen system. The valve is activated by expansion of an aneroid if the cabin pressure drops below a safe level. In expanding, the aneroid exerts a direct 1½-lb force against a column-loaded leaf spring. Once the leaf spring is deflected past center, the force is multiplied to 8 lb. This is sufficient to trip the trigger and release the oxygen valve.

Normally, cabins will be pressurized to a simulated altitude of 8000 ft or less. Oxygen equipment, however, must be instantly available if cabin pressurization should fail. Cruising altitudes of the jet liners will be between 30,000 and 40,000 ft, almost twice those of the present airliners.



METALLIC LUSTER in the colors of gold, brass, silver, chromium or anodized aluminum is featured in new plastic Spectro-Chrome by Schwab Plastics Corp. Clear or tinted translucent plastic is extruded around metallic cores. Spectro-Chrome is supplied straight or spiraled and in varied cross-sections. The cores are electrical conductors; the coatings, insulators.

First-of-type equipment is this line for processing tinplate from coils, now in operation at American Can Co. plant, Tampa, Fla. The line automatically inspects coil strip and cuts it into can-making sheets at speeds up to several hundred feet per minute. Projected new line will be still faster. New automatic chemical steps will enable making cans direct from coils.

Fast Machines Automate Tinplate Inspection, Shearing

Canmaking To Be More Automatic With New Enameling Units

TAMPA, FLA. — Tinplate for canmaking will soon be inspected, sheared and sorted automatically four times faster than the speeds of the presently available machines which perform only the shearing operation. Forerunner of the new equipment is a tinplate coil processing line recently put into operation by the American Can Co.

The Tampa coil line is the first of its type in the can making industry and one of a number of such installations Canco plans to open this year throughout the country. The coil lines automatically inspect, cut and sort sheets of tinplate and steelplate from coils weighing up to 15,000 lb at speeds up to 600 ft per minute. Formerly, steel mills performed these operations.

Steps in the coil stock process are:

Coils are moved from railroad gondola cars by heavy-duty cranes and lift trucks to an "up-ender" and from there to the uncoiling mandrel.

A series of rollers removes the curvature from the plate.

As the plate travels along the 100-ft line, electronic gages measure its thickness to tolerances of 0.0001-in.

The plate is visually inspected for surface appearance, and is further inspected electronically for pinholes.

An "electronic memory" device remembers any imperfections in the plate and automatically sorts out the sub-standard sheets after the plate has been cut.

High-speed shears cut the plate into sheets up to 36 by 36 in. while holding the length of the sheets within tolerances of 0.010-in.

The sheets are automatically sorted and stacked for shipment to can plants.

This new processor is only the basic unit of more extensively automated equipment now being developed, according to American Can Co.

The next step in Canco's program will be to incorporate equipment for chemically treating steelplate into its coil lines. Research is also advancing on the incorporation of enameling units into the coil lines. This would enable Canco to run the inspected, treated and enameled plate directly off the coils into can making machines without putting it through the sheeting operation. Work is also under way on the development of new, synthetic, fast-drying, high-polymer enamels and on construction of high-speed coating and drying equipment.

FACTS

about

NEW DEPARTURE BALL BEARINGS

NOW A NEW DEPARTURE IN PILLOW BLOCKS

- Clean, rigid, compact design.
- Free of any lubricating fixtures.
- New Departure ball bearings sealed and lubricated-for-life.
- Pillow Blocks easily mounted without special tools.
- Only high capacity precision ball bearings used.
- Accommodates any misalignment.
- 31 shaft sizes, ½" through 2 7/16".
- Interchangeable with most makes.

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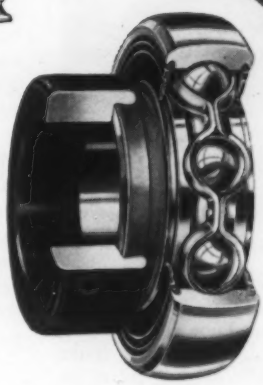
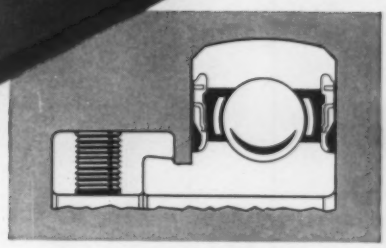
DIRT SEALED OUT
with
FAMOUS SENTRI-SEAL



New Departure Pillow Blocks employ the performance-proved New Departure Type AE Adapter ball bearings with spherical O.D. for alignability and steel-reinforced Sentri-Seals for long life protection against dirt or grease leakage.



The bearings are easily applied to the shafting and are positively locked in position with an eccentric cam locking collar and set screw.

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

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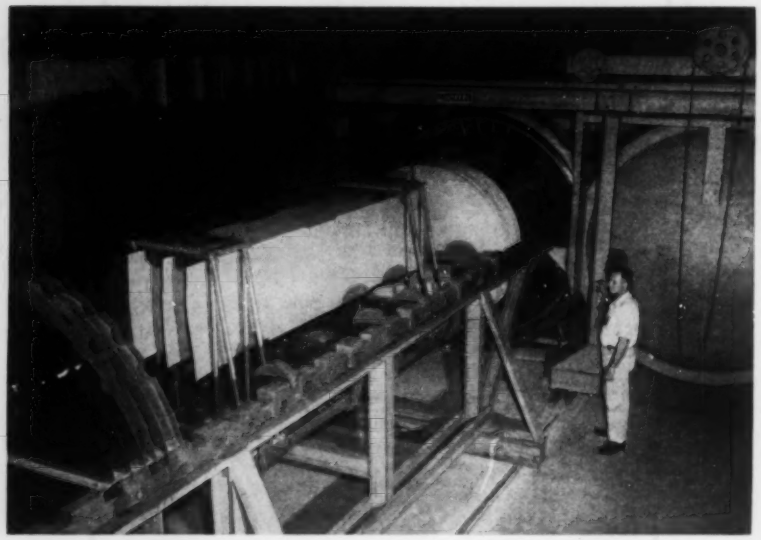
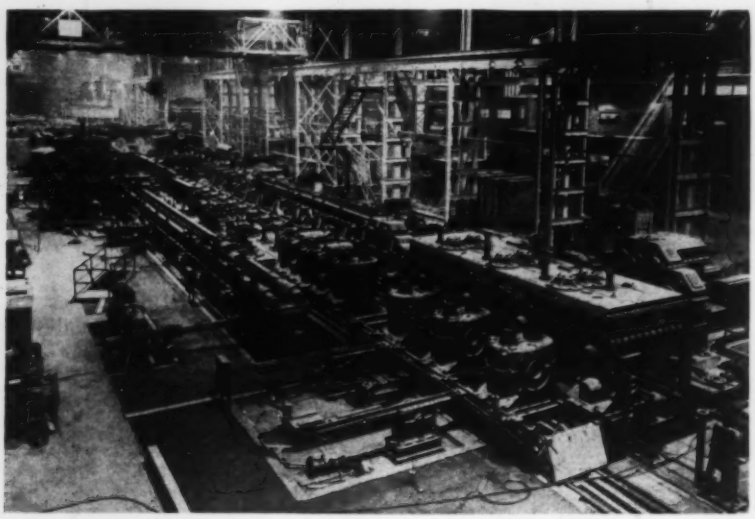
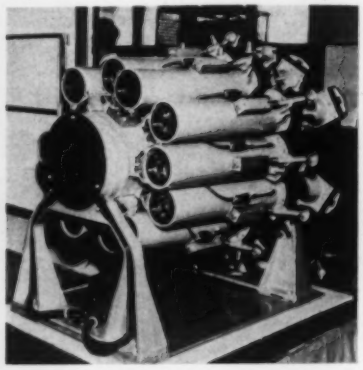


LARGEST HEAT TREATING VACUUM FURNACE is (claimed for) this unit recently built for North American Aviation Inc. by Lindberg Engineering Co. The furnace is more than 40 ft long; has a work chamber more than 14 ft long and 6 ft in diameter. Its 1400-cu ft volume can be evacuated to 0.3 micron in 23 minutes. Temperatures to 2100 F are possible, using 820 kw of power. Currently the furnace processes titanium parts for the SM-64 Navaho intercontinental supersonic strategic guided missile system. The installation will also be used for brazing sheet metal honeycomb. A tube cooling system has been built into the furnace for setting the braze prior to moving the treated metal into a cooling chamber.



AUTOMATIC SEAMLESS TUBE MILL, claimed the world's first automated to this extent, will produce steel tubes from $4\frac{1}{2}$ to $10\frac{3}{4}$ in. OD direct from steel rounds. It is installed in a Mannesman Tube Co. building $\frac{1}{4}$ mile long, 200 ft wide, at Saulte Ste. Marie, Canada. This view looks back toward the mill's furnace. In the foreground it shows a reeler to even wall thickness and a sizing mill to secure uniform tube diameter. Although highly automated, the mill will require an operating force of 500 men, mostly maintenance specialists. Annual production is planned to be 225,000 tons of finished seamless steel tubes, or 450 tons per man-year.



MICRO-SPLIT SECONDS are exposure times for this camera developed for Britain's Armament and Development Establishment. Actually an assembly of twelve cameras, the unit takes pictures with exposure times as short as 10^{-7}-second at intervals of 10^{-3}-second to less than 10^{-6}-second. Timing is entirely electrical. The camera was built primarily for photographic studies of the early stages of explosions.

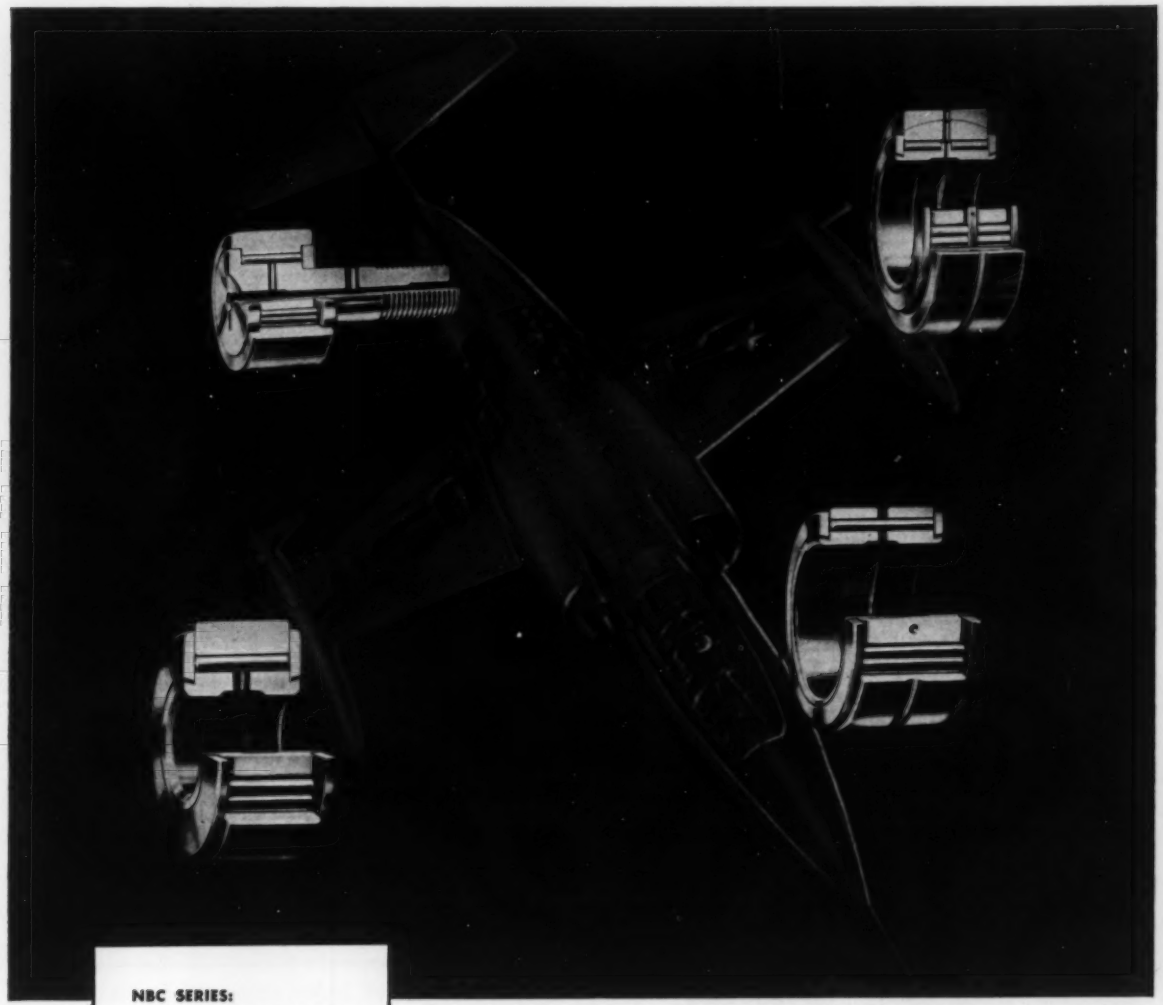
Efficiency Robots Now Check Automated Tool Performance

DAYTON, O.—To assure maximum efficency of a progressively more automated economy, machines themselves must now be time-studied, according to Kirk E. Birrell, project engineer of the Autometrology Div. of the Sheffield Corp.

While the problem of making the human element more efficient has been largely eliminated by automated processing, industry now faces the problem of seeing that automatic machinery also is operating at highest efficiency.

This job is being solved by the introduction of automatic machine efficiency "watchdogs," in the form of timing, cycle-recording and cycle-control devices which supersede inadequate methods of human observation. One such device is Sheffield's Monitorecord instrument now being widely applied to time and control automatic machinery.

The Monitorecord can measure the timing and cycle performance of a single tool or a complete production line. Data is recorded



NBC SERIES:
inner race, outer race, rollers and end washers securely fastened to inner race.

NBF SERIES:
extra heavy outer race for heavy rolling loads. Also available in double row NBL series.

NBK SERIES:
double row of rollers and self-aligning spherical OD outer race mounted in spherical ID ring.

CR SERIES:
heavy outer race and integral stud permitting cantilever mounting for use as cam or track roller.

Photo shows Lockheed's F-104A Starfighter, world's fastest, most advanced jet fighter, which is equipped with Torrington Aircraft Bearings.

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complete series of high-capacity Torrington Needle Bearings for aircraft application

Torrington Needle Bearings, offering maximum radial capacity in minimum cross section, are ideal for aircraft applications requiring dependable performance with light weight.

Torrington has developed four basic types to cover a complete range of application requirements. All are nonseparable units, made to AFBMA standards, constructed to have low radial clearance when mounted to keep vibration and backlash in mechanisms to a minimum.

Carefully selected quality steels and the most modern manufacturing methods are used in the production of these efficient aircraft-type Needle Bearings. At low unit cost, they bring efficient anti-friction operation for reliable performance and long service life. For further information on their selection and application, just call your nearest Torrington representative or write: THE TORRINGTON COMPANY, Torrington, Conn. — and South Bend 21, Ind.

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without any need for extensive machine tool modifications. This is accomplished by making electrical connections to terminals already existing on the control panels of the machines to be monitored. Terminals are selected which give elemental sequence start-and-stop times when energized or de-energized. Thus, connecting these terminals through a receptacle to the sequence-time recorder in chronological sequence makes possible a bar-chart "picture" of the simultaneous and/or sequential operational events. This shows start-and-stop relationships with an accuracy of 0.01 seconds, and is available as a permanent record for further analysis. With these bar charts, machine adjustments affecting production rates can be made after a thorough appraisal of all of the sequences composing a total repetitive cycle.

Monitorecord can be installed and read from remote locations, so that production engineers can obtain instantaneous plant-wide performance data at a glance.

INSTRUMENT DISPLAY PROJECTOR, developed by Autonetics Div. of North American Aviation Inc., gives essential information for an instrument landing, and at the same time allows visual contact outside the airplane. Components are a cathode ray tube of 1½ in. diam, a mirror system, collimating optics, and a trichroic combining glass that uses color contrast to enhance definition of a reflected image. Color enables definition even against a bright sky background. Cathode ray tube's image is reflected by the mirror system to the collimating optics, then to the color-separating combining glass. Flight data is a bright green image appearing to be suspended in space. Color contrast principle enables display to operate on low 4000 v.

FIRST AUTOMATIC TRANSMISSION for an outboard motor is this small Mercury unit weighing less than 2 lb, yet incorporating a planetary gear system. It is installed at the point shown in the drive train. The transmission was developed by Kiekhaefer Corp. for the 10-hp Mercury Mark 10 motor. It gives boatmen one-hand control of forward, reverse and neutral operation, as well as speed and direction, in one twist grip on the tiller handle.

Aluminum Solder Developed for High Temperature Applications

PITTSBURGH, PA.—New high temperature soldering materials for aluminum have been developed by Aluminum Co. of America. Alcoa Solder No. 805 (95 per cent zinc, 5 per cent aluminum), has been used successfully in joining heat exchanger return bends, electrical connections, automobile radiators, transition joints and fins to tubing. It will join all aluminum alloys, and make joints between aluminum and other metals such as copper, brass, steel, stainless steel and nickel.

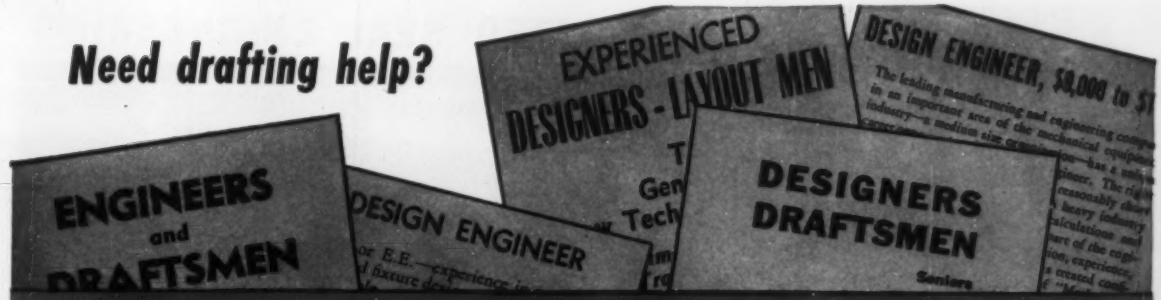
With a melting range of 715 to 725 deg F, the new solder can be heated by any of the conventional methods. It works most effectively when preplaced in or near a joint, rather than being fed manually. Strength of the corrosion-resistant joints made with Alcoa Solder No. 805 is directly dependent on lap length. Solder No. 805 could be used to make high temperature joints that formerly had to be brazed or welded.

Alcoa Soldering Flux No. 66, recommended for use with the new solder, can be applied dry, or as a 70 per cent flux—30 per cent normal propyl alcohol solution. It reacts at 720 deg F to wet aluminum with zinc, and there are no restrictions regarding the method of heating. Immediately following the soldering operation, the flux can be removed by flushing with water heated to 180 F.

First transportable caesium atomic clock has been developed for the Royal Aircraft Establish-

(*Continued on Page 22*)

Need drafting help?



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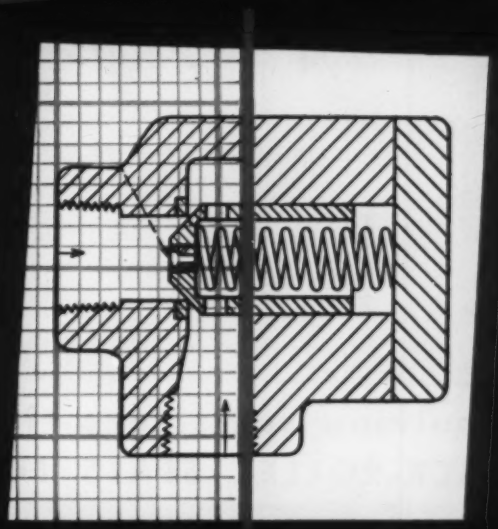

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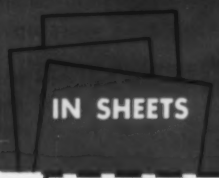

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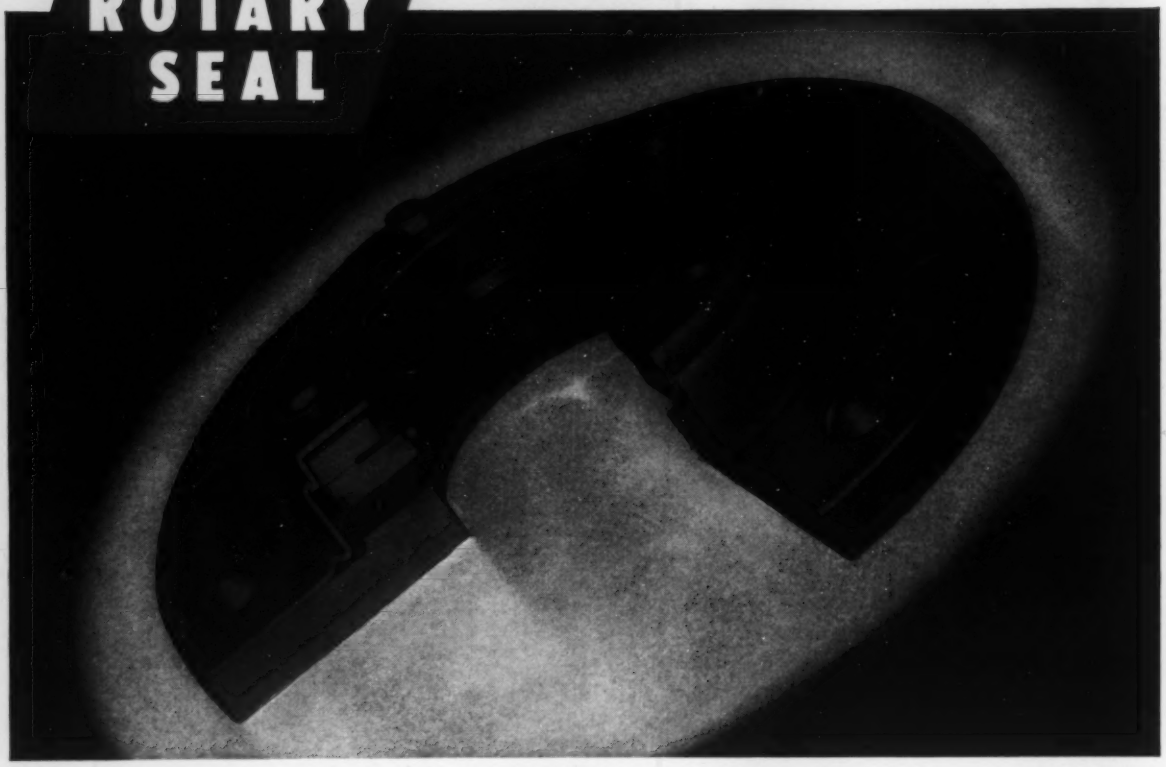
ROTARY SEAL

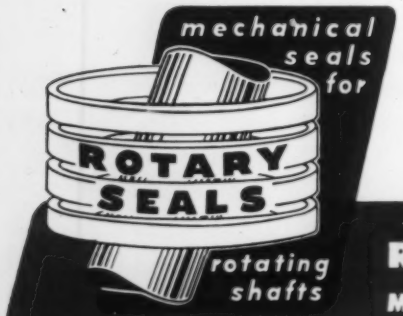
SPECIALIZED SEAL ENGINEERING



is solving some long-time headaches in developing TRACK-ROLLER SEALS FOR CRAWLER-TYPE TRACTORS

No simple task, this—to get the bugs out of an old bugbear in the heavy-duty machinery field. Months and months of effort—guided by years and years of specialized experience—have gone into the development of the track-roller Seal illustrated. But it solves the old problems of sealing dirt out, sealing lubricants in, with a completely self-contained unit. This Seal, specially developed for a leading Mid-West manufacturer of machinery, exemplifies the skill and patience of ROTARY SEAL engineering. That's our business—solving hard Shaft Sealing problems where production quantities of Seals are involved, by applying the basic ROTARY SEAL principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago.

The best time to start solving your Shaft-Sealing problem is at the drawing-board stage. Call in our engineers for an early consultation—our experience with Seal applications of all kinds in many fields often indicates suggestions which can simplify design, lower costs and improve performance.



Shaft-Sealing with Certainty

ROTARY SEAL DIVISION

MUSKEGON PISTON RING CO., SPARTA, MICHIGAN

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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FIRST CLASS
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CLEVELAND, OHIO

BUSINESS REPLY CARD
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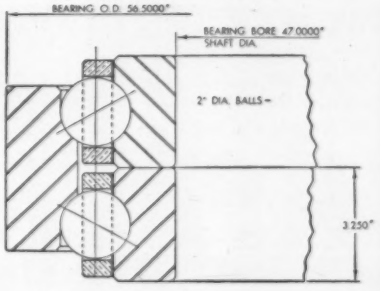
Here are the bearings that "couldn't be built"... *as produced by Kaydon*

THE manufacturer who wanted these bearings had been told they "couldn't be built." Or at least that's what he'd been told *until* he contacted **KAYDON**. What he required was a bearing 56½" in diameter combining high capacity, and exceptional precision for concentricity and face runout that would fit in limited space.

KAYDON designed a double-row angular contact ball bearing (see sketch at right). Actual tests have proved that the bearing fulfills every requirement.

If your designs require bearings of exceptional capacity, close-tolerance precision and/or very thin section — it will pay you to contact **KAYDON** of Muskegon. **KAYDON** has a long-standing reputation for accomplishing the near impossible.

CROSS SECTION — *The bearing that couldn't be built*



Just Out! Get your copy of the new **KAYDON** *Reali-Slim thin bearing catalog No. 54.*

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
• Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K543

PRECISION BALL AND ROLLER BEARINGS

Circle 413 on page 19

(*Continued from Page 14*)
ment, England. It uses the vibrations of caesium atoms as a source of time-keeping. Accuracy is one part in one billion or better. Heart of the instrument is in a vacuum tube 2½ ft long; less than 3 in. wide. It can be used either for control of radio frequencies or for direct measurements of time.

Off-Road Dump Truck Said Largest with Single Engine

Frame of Autocar AP-40 Made of One-Inch Plate

EXTON, PA. — Most powerful single-engine truck in the industry is claimed by Autocar Div. of White Motor Co. for its new model AP-40 dump truck. Designed for off-highway operation, the new truck carries loads of 40 tons at speeds up to 33 mph. It is the first truck to have more than 600 hp in a single engine.

The AP-40 is more than 13 ft high, 31 ft 10 in. long, and equipped with a 27-cu yd body. Its V-type, turbocharged 12-cylinder Cummins diesel was previously used only in locomotives and as a stationary power plant for oil-field operations. The rated 600 hp is at 2100 rpm engine speed. Bore is 5⅛ in.; stroke, 6 in. Compression ratio is 13.5. Piston displacement is 1486 cu in.

The all-steel and welded cab is enclosed and offset mounted. Cowl is recessed. Width of the cab is 84½ in. The steering wheel can be adjusted through an arc of 15 degrees and raised or lowered through 2 in. Driver's seat is also adjustable. Steering is manual with hydraulic assist.

The rock-type body has chute construction and scoop end. It is all welded; has sandwich-type double bottom with formed box-section reinforcements. Dumping angle is 70 degrees.

Two-shoe, internal - expanding brakes are completely air operated on all six wheels. Front-wheel shoes are 20¼ by 5 in., rear-wheel shoes are 20¼ by 5 by 2 in. There are four air chambers on each rear axle. Tires are 18.00/25, have 24-ply rating, rock-lug tread.

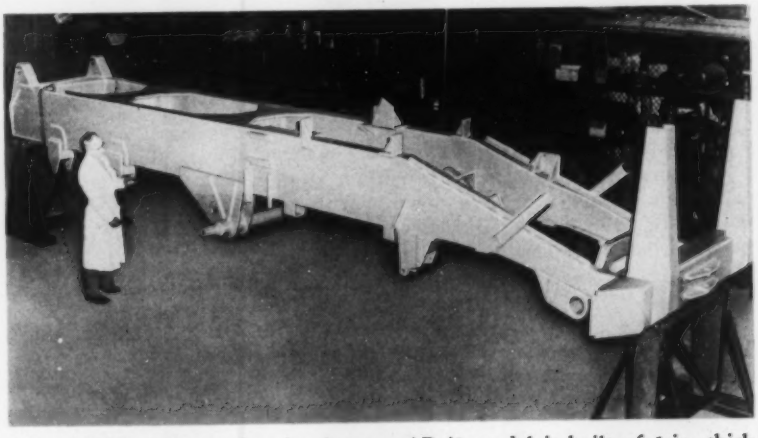
Silver Ink Impressions Now Made from Printed Circuits

PHILADELPHIA, PA.—Printing circuits with silver ink is a technique developed by the J. Frank Motson Co. and recently introduced commercially. The conductive ink is applied only where the circuitry requires, with consequent elimination of etching.

Motson circuits may be applied to a base of most geometrical shapes including the inside or outside of tubes, the surfaces of flats, cylinders, spheres and cones. Choice of base material includes cellophane, cellulose acetate and butyrate, vinyl chloride and acetate, acrylics, styrenes, polyesters, nylon, mica, paper, wood, ceramics and glass.

High adhesive qualities are obtained through variations in ink formulations. Lines as narrow as 0.005 ± 0.001 in. can be copied.

Off-highway operation in mining, quarrying and construction is intended for the new Autocar AP-40 model. Claimed the most powerful single-engine truck, it hauls 40 tons at 33 mph. It has planetary gear reduction drive at the ends of rear axles.



All-welded box frame for the Autocar AP-40 model is built of 1-in. thick carbon steel plate, reinforced within by corrugated plate ¾-in. thick. It has seven cross-members. Weight is 16,800 lb. Frame side section is 5½ in. wide, has maximum depth of 23½ in.

FOR "BUILT-IN" PRODUCTIVITY

Lead existing in alloy or carbon steels in the form of sub-microscopic particles acts as a natural lubricant. Its effect on your operating costs will be pleasantly surprising.

Faster speeds, faster feeds, better finish and longer tool life possible with these free machining steels are helping hundreds of manufacturers to increase production and to lower costs.

See what "lubricated" steels can do for you—specify leaded on your next Aristoloy order. Get the cost-cutting benefit of "built-in" productivity.

For further details, write for free booklet, "Lead Treated Steels."

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY • WARREN, OHIO
Steel Division
EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

Circle 414 on page 19

Number of Engineering Grads Takes Turn for Better

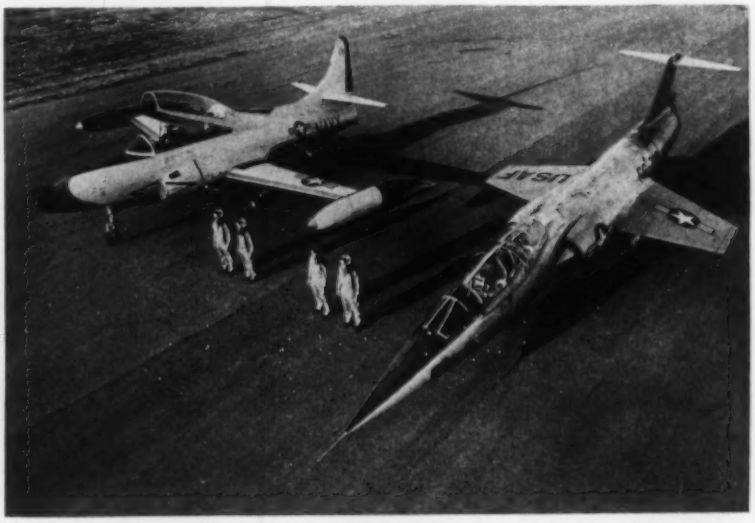
WASHINGTON, D.C.—The first increases since 1950 in the numbers of new engineering graduates have been reported recently by the Office of Education. The data, summarized by the Engineers Joint Council and the Scientific Manpower Commission, may indicate a turning-point in the technical manpower situation.

The summary shows that the number of Bachelor's degrees awarded in all fields at the end of the school year 1955-56 was 12 per cent greater than the corresponding total for the preceding period. A substantial portion of the increase occurred in the combined branches of engineering. Increased numbers of engineers earned Master's and Doctor's degrees in the respective periods, but the percentage increase is one-half to one-quarter the rate of increase in the number of those who earned Bachelor's degrees.

It is observed further that engineering graduates comprised a greater percentage of all graduates in 1955-56 than in 1954-55. This is true for all three academic levels.

Earned Degrees, 1954-55 and 1955-56

	Bachelor		Master		Doctor	
	1954-55	1955-56	1954-55	1955-56	1954-55	1955-56
Mathematics	4,034	4,660	761	892	250	224
Physical Sciences	10,516	11,672	2,544	2,640	1,713	1,635
Engineering	22,589	26,312	4,484	4,724	599	610
Total (Sc. & Eng.)	58,891	66,016	12,055	12,451	4,751	4,521
All Fields	287,401	311,298	58,204	59,370	8,840	8,815



SOON TO SERVE in the Navy and Air Force, respectively, are the Lockheed models T2V-1 SeaStar (left) and the F-104B Starfighter. The SeaStar, a carrier-based trainer scheduled to enter service in mid-1957, is called by pilots the safest jet ever built. The F-104B is a two-place version of the ultrasonic F-104A. It is claimed the fastest and highest-flying two-man fighter in the world. Starfighters are scheduled to enter operational service first with the Air Defense Command and later with the Tactical Air Command.

SWEPT-WING DESIGN now appears in Dodge light-load utilitarian models. This high-style truck is designated Sweptside 100. Its wheelbase is 116 in.; inside cargo bed length, 90 in.; corresponding inside width, 54 in.; payload capacity, 1675 lb; cargo volume, 56¼ cu ft. Powerplant can be 204-hp V-8 or 120-hp 6-cylinder engine. Power brakes, power steering and three-speed, automatic transmission are available. Sweptside is offered for businesses and vocations in which owners need a fashionable truck.

Small Tape Recorder Takes Long Talks

NEW HAVEN, CONN. — Twenty-four hours of continuous unattended recording is now possible with a magnetic tape recorder/reproducer developed by the Sound-Scriber Corp. Tests have been completed with the Armed Services and aircraft industries. The device has also been tested in the electric power industry for load dispatching and in radio broadcasting for documentation.

The tape is calibrated in minutes from 0000 to 1455 for precise and convenient place finding. Lengthy recordings are attained by a slow tape speed of 2½ in. per minute. Tape storage reels are small—measure 3¾ in. diameter and 2 in. wide. The recording pattern is such that alteration of the matter recorded is impossible without detection.

Communications may be monitored through an external headset. Inputs are telephone, line, and microphone. Outputs are speaker and headset. Operating voltage is 115 v, 60 cycles, ac.

Drafting Department Heads!

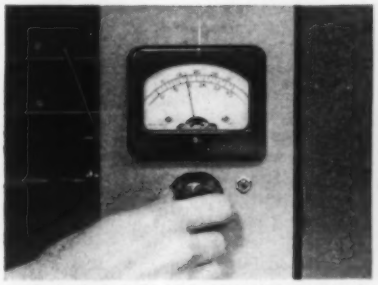
Your older reproduction equipment may be costing you valuable time and man hours!

Get All These Modern Reproduction Advantages with Copyflex!

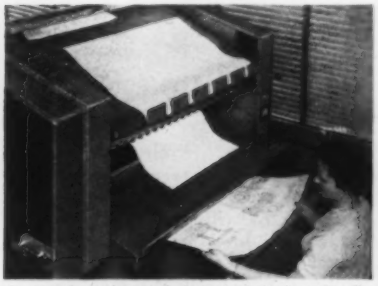
Right now, with production boom demands growing, is the time to take a good look at your reproduction equipment. If it's more than a few years old, chances are it's costing you unnecessary time, man hours, and money.

Compare the performance and features of your equipment with the advantages of modern Copyflex, typified by the Model 500 shown above. You should be getting the time and manpower savings offered by its greater mechanical speed, faster return of originals, automatic separation, front or rear delivery—all these plus the problem-free installation and operation of Copyflex. Seven other great models offer comparable advantages.

If you're not getting these important benefits, then every day you delay getting Copyflex is costing you time and money. Act now by mailing the coupon. You'll be glad you did!



Faster Mechanical Speeds! New Copyflex models introduced within the past two years offer sharply increased speeds—up to 30% faster than before. Synchronized exposure and development assure top quality prints, one knob control simplifies operation.



Greater Convenience of Operation! Modern Copyflex gives printing widths up to 54" to simplify feeding of large tracings, facilitate multiple feedings. Such features as extra-large delivery trays, automatic separation, front-or-rear delivery further speed operator's work.

Problem-Free Installation and Operation! Clean, quiet, odorless . . . Copyflex requires no vents or plumbing. Precision-engineering design, including use of selenium rectifiers instead of troublesome vacuum tubes, assures trouble-free operation of all models, large or small.

BRUNING *Offices in 38 Cities of the U.S. and Canada*

Best Process!
Best Machines!
Best Selection of Materials!

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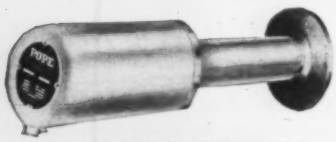
City_____ **County**_____ **State**_____

POPE engineers and builds 20,000 DIFFERENT MOTORIZED AND BELT DRIVEN SPINDLES

one of which may be just the one to LOWER YOUR PRODUCTION COST

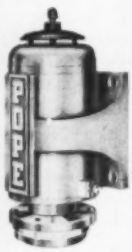
Here are only a few representative Pope Precision Spindles:



FOR SURFACE GRINDING

POPE 1, 2 and 3 HP Totally Enclosed 1800 and 3600 RPM Motorized, Cartridge Type Spindles with double row cylindrical roller bearings of enormous capacity for superior performance and long life, plus separate thrust bearings for no endwise movement of the shaft.

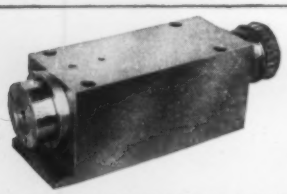
FOR HEAVY DUTY MILLING AND GRINDING



POPE ¾ to 100 HP Direct Motorized Spindles operate in any position — flanged or tapered noses — equipped with super-precision, double-row roller bearings and preloaded ball thrust bearings. Top quality performance is assured on skin milling, grinding, boring and other operations as well as milling.

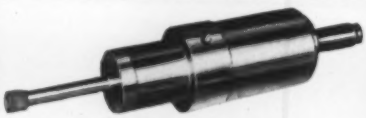
FOR TOOL AND CUTTER GRINDING

POPE Super-Precision 1 HP, 3600 RPM Motorized Tool and Cutter Grinder Clearance Angle Swivelling Heads provide angular adjustment in a vertical plane. They pay for themselves in time saved. Cup wheels can be used for practically all clearance angles.



FOR BORING ROUND HOLES WITHIN MILLIONTHS OF AN INCH

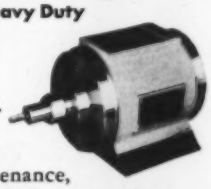
POPE Heavy Duty Boring Spindles assure smooth, chatter free, continuous high production of accurate parts. Belt driven or motorized, in a wide range of horsepowers and speeds.



FOR INTERNAL GRINDING

POPE Precision Internal Grinding Spindles have the super-precision bearings to withstand both axial and radial loads and to produce better finished ground holes. Their ability to take heavy cuts means increased production. Wheel life is increased, too. For Bryant, Cincinnati, Excello, Heald, Landis and Norton Grinders.

FOR HIGH CYCLE GRINDING AND MILLING



POPE Super-Precision, High Frequency, Heavy Duty Spindles are available for speeds up to 100,000 RPM. They are unequalled for low cost maintenance, long life, trouble-free operation and rugged ability to cut metal fast.

Send us your specifications and get prompt quotations on the one best Spindle for you out of the 20,000 different Precision Spindles that bear the name "POPE."

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Established 1920

Defense Digest

World's first fleet-type nuclear submarine, *USS Skate,* was launched recently at Groton, Conn. Designed for assembly-line production, *Skate* is 25 per cent smaller than the *Nautilus,* but has similar speed and range characteristics.

The Navy's current nuclear-propulsion building program includes three sister ships of *Skate,* seven more attack submarines of another class, one radar picket submarine, and one newly designed guided missile submarine. The picket submarine, *Triton,* will be the largest submarine ever built and the first to have two reactors.

• • •

Toss bombing has been demonstrated publicly for the first time by the 100-ton, six-jet B-47 bomber. The Boeing Stratojet enters its bombing run at low altitude, pulls up sharply with a half loop, and releases the weapon at a predetermined point. The weapon then describes a high arc, falling on the target a distance from the point of release as the B-47 speeds away in the opposite direction.

• • •

New reactor core for the *Nautilus* has been installed in recent refueling operations. Simpler, less expensive, and more reliable, the new core also includes technical advances expected to extend fuel performance. The *Nautilus* steamed more than 60,000 miles on her original supply of nuclear fuel, including one run of 1217 miles fully submerged at an average speed of more than 20 knots.

Bomarc antiaircraft missile has been ordered into production by the Air Force. Developed by Boeing Airplane Co. with extensive co-operation from other sources, Bomarc is said to be a highly successful interceptor-type weapon. The missile is about 47 ft long, weighs 7½ tons and has a wing span of 18 ft 2 in. Bomarc is launched vertically by a liquid fuel rocket motor. Once airborne, power is furnished by twin ram-jet engines.

• • •

Underwater television camera has been developed for the Navy by the Admiral Corp. Light from an ordinary match reveals as much to this camera as a man with 20/20 vision sees in the light of a 150-w electric bulb, according to the company. The camera is used in conjunction with a television monitor on which the phase of the signal can be reversed and the picture size can be controlled independent of linearity.

• • •

Guided-missile frigates of a new class will be equipped with Terrier launching systems, according to the Defense Dept. Recent contracts for the frigates also provide for guided-missile launching systems to be installed on the Navy's first nuclear-powered cruiser, and on the new carriers *Kitty Hawk* and *Constellation.* The Terrier systems load the launchers from magazines, train, elevate, and fire the missile. Maximum automation is a design objective.

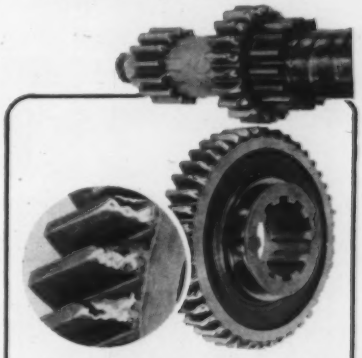
Company Sees Engineers Spurred by Profit-Sharing

LOS ANGELES, CALIF.—Profit sharing with engineers is part of a "far-sighted and stimulating creed" for employee motivation at Packard-Bell Electronics Corp., according to Dr. Robert S. Bell, company president. Dr. Bell told a meeting of the Institute of Radio Engineers that his firm sets aside ten per cent of annual net earnings before taxes for distribution in the form of company stock.

When one engineer comes up with a good idea, other engineers are not inclined to be unhappy, Dr. Bell reported. That idea may represent a larger dividend on present stock and a larger stock sharing in the future.

The creed also calls for the corporation to remain compact regardless of size and for employees to work in small groups so that talent can be recognized quickly. The creed requires management to delegate authority as well as responsibility. From employees, it requires

The Potential Gold Mine in these Gears never paid off!



• These gears could have remained youthful and productive for some 20 years of service—should have helped to produce many times as much as they did. Instead, they were noisy, failed prematurely — caused losses and damaged reputations that could have been avoided by consulting Sier-Bath at the design and manufacturing stage.

There is only one best gear design for each application. Have Sier-Bath manufacture it into your gears to eliminate gear troubles and failures, and most important, gain economies and add operating advantages that keep your machines ahead of competition and geared to the increased requirements of tomorrow.

Our chief gear engineer was for many years a gear consultant serving most of the nation's leading gear manufacturers. Solving gear problems and gear failures is the forte of the staff he has developed since becoming our chief gear engineer. This staff is at your service to help you obtain gears of the best design — analyze your drawings—study your application—provide free engineering consultation to achieve maximum loads, speeds, precision and life expectancy, with a minimum of size and cost of your gears.

Send us your gear prints or problems for study and quotation. Or, have a Sier-Bath specialist call to discuss your gear requirements.

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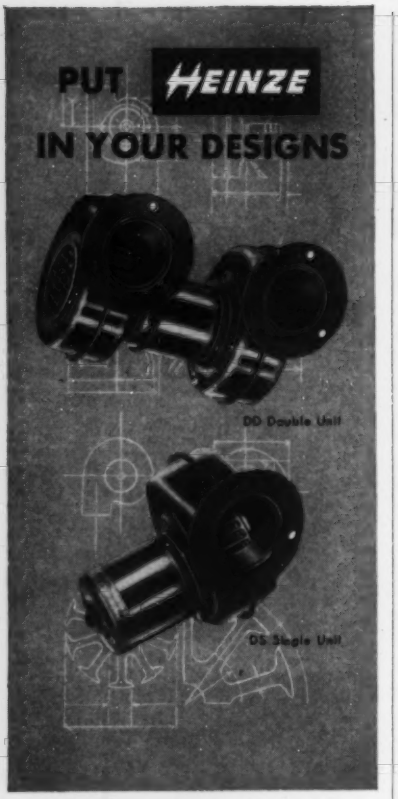
Sier-Bath PRECISION GEARS

All kinds of gears—all materials
Made—cut—shaved—ground tooth
42" maximum diameter
12 or more of a kind, depending on size.

Circle 417 on page 19



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simple maintenance

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685 Lawrence St., Lowell, Mass.

SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

Circle 418 on page 19

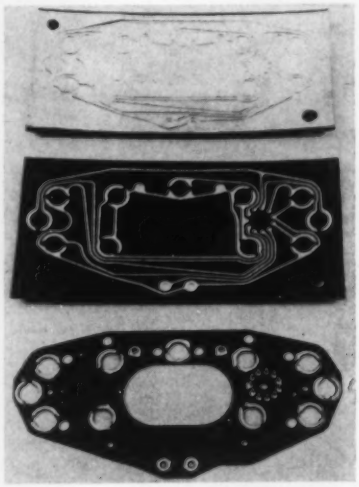
personal responsibility and loyalty to company and supervisor.

Process Enables 3-D Printed Circuits To Be Mass Produced

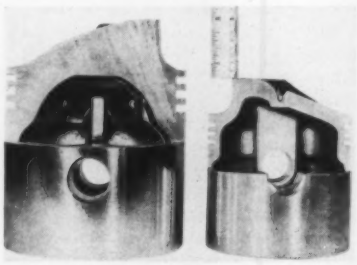
ROGERS, CONN. — Three-dimensional effects are now obtained in volume production of printed circuits by the use of molding techniques recently announced by the Rogers Corp. The new method eliminates etching and plating operations and permits molding-in of three dimensional details at the same time the circuit itself is formed.

Basis of the new process is a phenolic impregnated cellulose sheet material also developed by the Rogers Corp. Designated RM 2035, the material meets specifications up to NEMA XXXP standard. Moldings prepared from RM 2035 can incorporate such features as inserts, molded pins, tapered holes, flanges, ribs, and metal foil inlays. Hole concentration can be twice that of punched XXXP parts. In addition, the molding process can form a resin skin seal over edges and hole walls, to reduce moisture absorption.

Several production methods are possible. In one process, a continuous adhesive-backed copper strip is die stamped into the board prior to molding. The punch impresses the copper below the surface of the board, adhering those parts which will form the circuit. Excess copper is stripped away and standard compression molding techniques complete the unit.



Mass-produced, three - dimensional, molded circuit by Rogers Corp. Top to bottom: design in copper stamped in the molding board, pattern on the board with excess copper stripped away, the completed circuit.



PISTON WEIGHTS DECLINE as engineered improvements are made in new models of Mercury outboard motors by Kiekhaefer Corp. Differences between these two represent 10 years' change. On the left is the old cast type with a massive dome of metal to keep the piston from melting under extreme preignition heat experienced with large bores. Modern drop forged aluminum piston on the right has a smaller bore and a much lighter dome permitted by low combustion heat in new outboards.

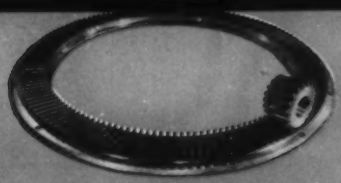
Air Weapons Trend To Cause Major Industrial Adjustments

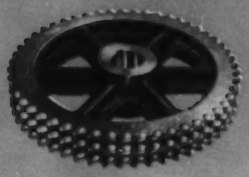
Missile Emphasis Is Decisive

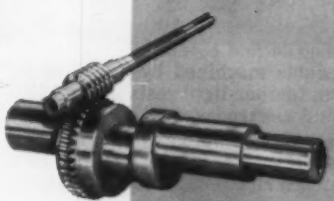
WRIGHT PATTERSON AFB, O. — Major adjustments that are likely to be made over the next few years in the aircraft and supporting industries were outlined recently by Gen. David H. Baker, director of procurement and production for Air Materiel Command. Largely responsible for the impending adjustments is the fact that emphasis upon missile technology has resulted in fewer manned combat aircraft. Gen. Baker discussed the probable effect this will have on industries supplying weapons systems and their components.

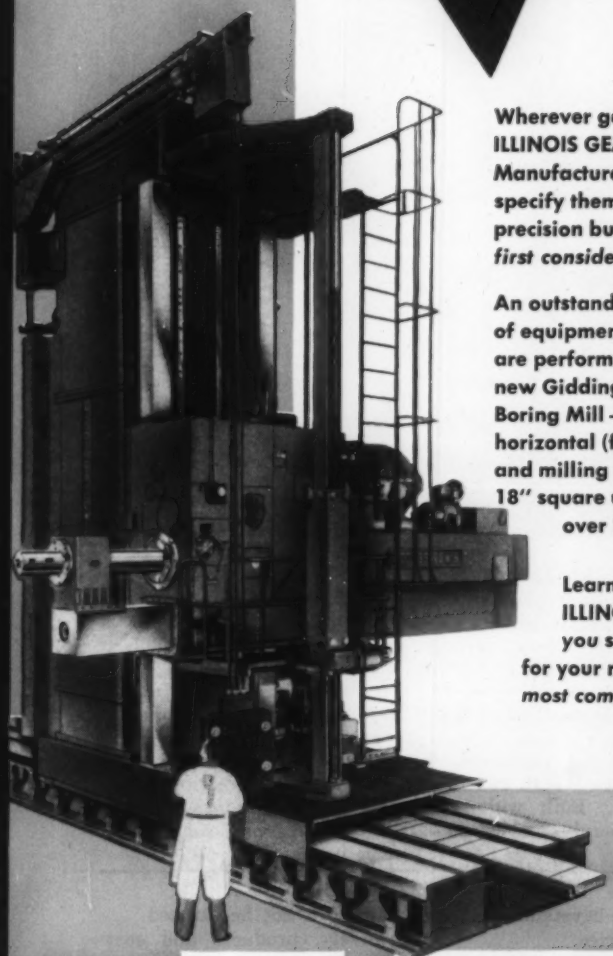
Two major industries were singled out: Those producing structural parts—airframes and missileframes, and producers of special-

Gears For every Purpose









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Circle 419 on page 19

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Versatile and economical ... carbon products machined by Speer range from feather-light resistors to 1300-pound electrodes.

Speer carbon may help you improve product performance... reduce unit costs. Write today for full details.

Carbon Is Versatile!

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Sawed	High corrosion resistance
Drilled	High heat transfer
Milled	Low electrical resistance
Broached	High thermal shock resistance
Turned	High heat transfer (graphite)
Planed	
Hobbed	Is:
Ground	Non-warping
Molded	Non wetted by molten metals
Extruded	Chemically inert
	Self-lubricating (graphite)

SPEER Carbon Co.
St. Marys, Pennsylvania

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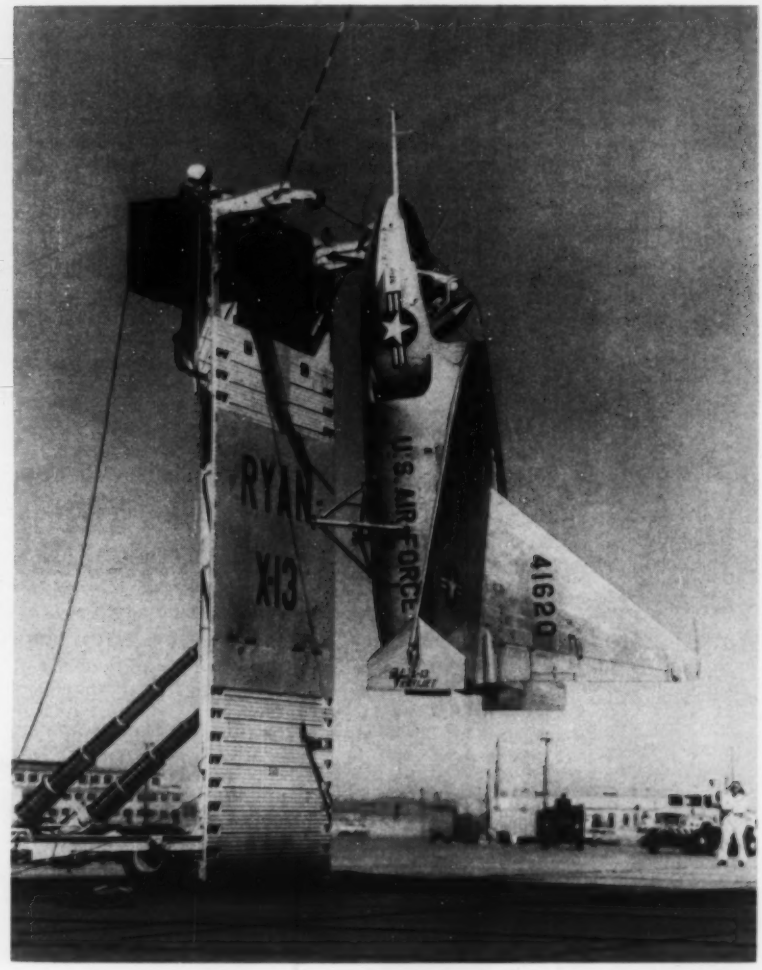


FIRST PILOTED HOVERING JET FLIGHT has been performed in this Ryan X-13 Vertijet research plane. First photo made public by the Air Force shows the VTOL craft and its ground service trailer. The X-13 is powered by a Rolls-Royce Avon turbojet engine rated about 10,000 lb thrust. Its shoulder-high wing is delta-shaped for best high-altitude, high-speed operation. Length of the plane is 24 ft; wing span, 21 ft; height, 15 ft. Most unusual feature—key to jet VTOL flight—is the jet-reaction control system. Necessary control forces are developed by jet engine exhaust deflection and thrust variations. With the usual stick and rudder pedals, the pilot operates VTOL controls as well as the conventional type for conventional flight. Built without wheels, the X-13 hooks onto its handling trailer; is ground-transported, horizontally, on the same vehicle.

ized equipment and subsystems—electronics and accessories.

Within the next few years, airframe industries will experience a decreasing demand for their products and services. By 1959-60, 70 per cent of the current manufacturing capacity of this industry, measured in terms of sq ft of factory area, will not be utilized.

Conversely, products and services from the specialized industries will grow in complexity and require greater total effort. Gen. Baker noted, however, that "A large segment of the specialized industry has adopted a policy of 'wait and see' with respect to work-

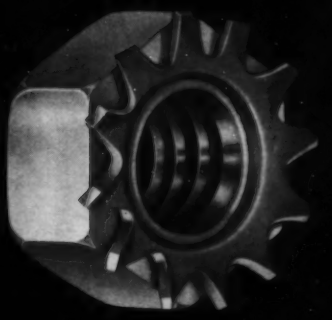
handle

One Unit

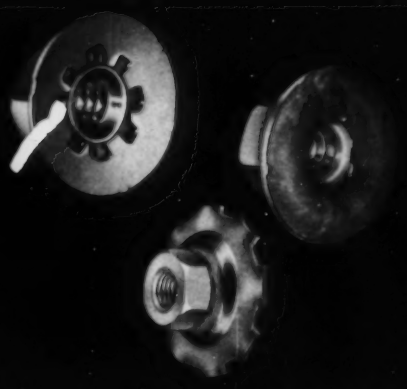
instead of

Two or More

cut costs instantly!



KEPS* pre-assembled nut and Shakeproof® Lock Washer



Each of these Keps replaces three separate units for greater savings: Dished and Domed Washer Keps for extra strength and holespanning; Sealing Keps for sealing out water, oil, gasoline or air.

• Keps end separate nut and lock washer handling • Often eliminate many extra fastening parts • Provide positive locking action, maximum product protection • Washers can't get lost, mismatched or forgotten • Available in broad range of styles, materials and sizes.

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Circle 421 on page 19

ing with the prime weapon systems manufacturers. The trend to fewer systems and fewer prime contractors should be examined closely by these people and appropriate plans and action taken or they may find themselves precluded from the future systems markets."

The weapons systems concept, resulting in prime contract arrangements, has led to considerable misunderstanding. Both Air Force intentions and the effect upon industry have been seriously misinterpreted by many members of fully automatic fire is 700 Baker.

"First, and most importantly, we are not, through this concept, building an integrated munitions industry comprised of our aircraft and missiles prime contractors. What we are doing is giving the weapon system prime contractor more and more responsibility for specifying what must go into the new system and for managing and integrating the engineering and development effort which is required for the system. The utilization of skills and capabilities existing in other companies and industries is an essential requirement of this concept.

"A second misapprehension is that the production responsibilities will follow the pattern of the development responsibilities vested in the prime contractor. It is at this point that we step in—in the procurement process—and establish a prime contract relationship with the firm which has developed the major subsystems or equipment."

U.S. Army photograph

U.S. Army's new standard rifle, the M-14, replaces the familiar M-1 (Garand); fires 7.62-mm NATO cartridge from a 20-round magazine; will go into mass production for issue to troops in 1960.

New Army Rifle Completes Small Weapons System

Auto/Semiauto M-14 Lighter Than M-1, Fires NATO Ammo

WASHINGTON, D.C.—American military riflemen in the future will carry a lighter weapon and deliver more fire than they did in WW II or in any earlier conflict. The Army has announced adoption of a new rifle, designated M-14, to replace the M-1 (Garand) rifle, the 30-caliber carbine, the M-3 submachine gun and the Browning automatic rifle. The M-14 was developed by the Army Ordnance Corps at the Springfield (Mass.) Arsenal.

The M-14 uses the 7.62-mm (caliber 30) NATO standard cartridge, also developed by the U.S. Army, and is capable of either fully automatic or semiautomatic fire. Rate of fully-automatic fire is 700 rounds per minute. Its magazine capacity is 20 rounds.

There are two barrels for the new rifle. With the lighter of the two, the rifle is designated M-14 and weighs 8.7 lb. Fitted with the heavier barrel and a tripod, the rifle is designated M-15 and weighs 13 lb.

Muzzle velocity of both the M-14 and the superseded M-1 is 2740 ft per second. Overall length of the M-14, with flash hider, is 44.25 in. Without flash hider, length of the M-1 was 43.6 in.

The 7.62-mm cartridge is lighter and shorter than the ammunition

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MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL
Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.
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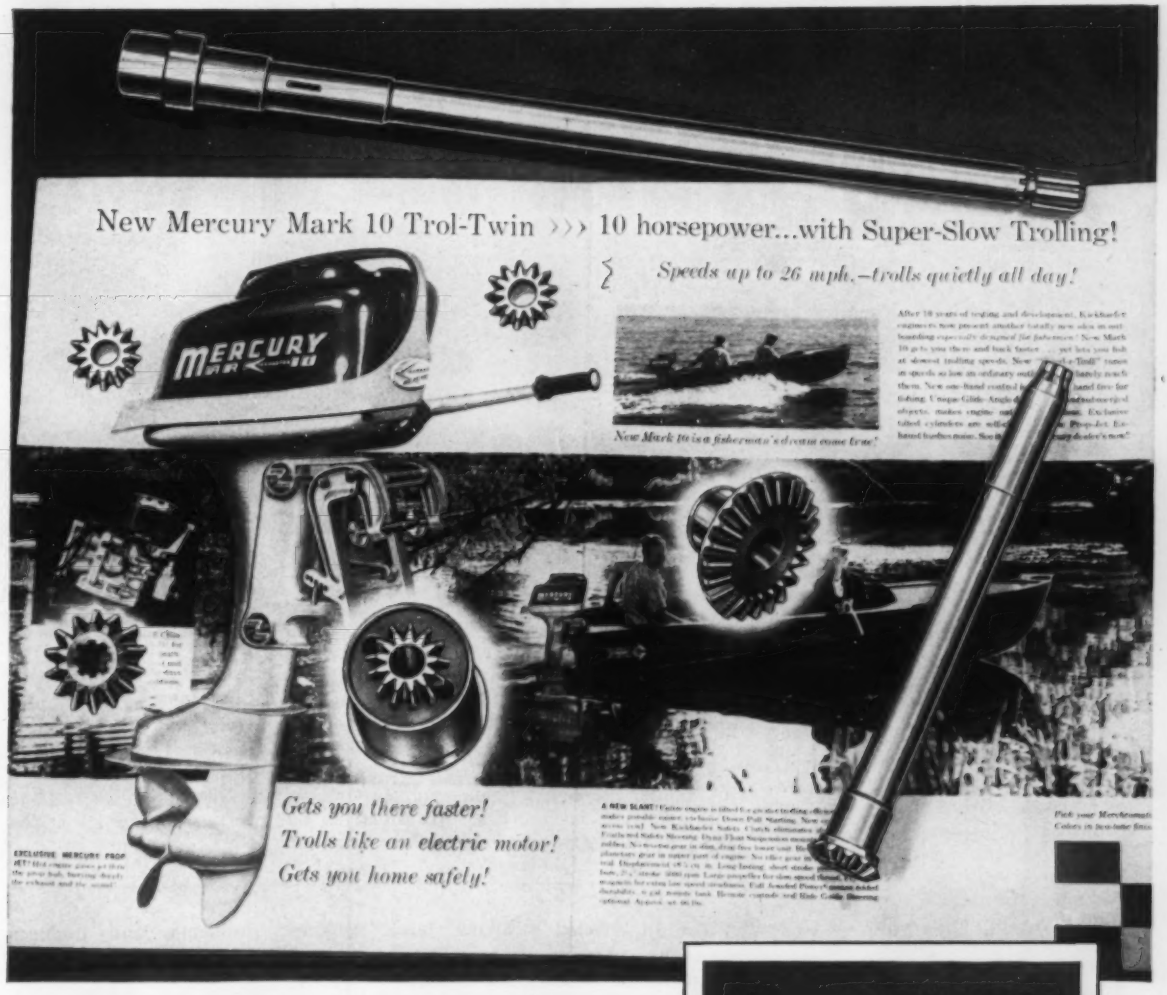
Circle 422 on page 19


New Mercury Mark 10 Trol-Twin ››› 10 horsepower...with Super-Slow Trolling!
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Trolls like an electric motor!
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The rugged new MERCURY Mark 10 Outboard, with Gearing by G. S., offers *the first automatic transmission in the industry!* The unique transmission engineering development permits one-hand control of throttle, neutral, forward and reverse with the twist-grip on the tiller handle. ★ You, too, can depend upon G. S. for TOP performance in the Gearing you need. Skilled G. S. engineers will gladly lend you valuable aid in determining the ONE best, and most economical application. Send drawings and descriptions today.

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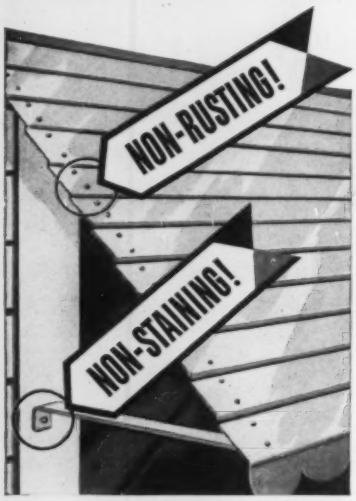
How Alcoa Aluminum Fasteners make good awnings even better



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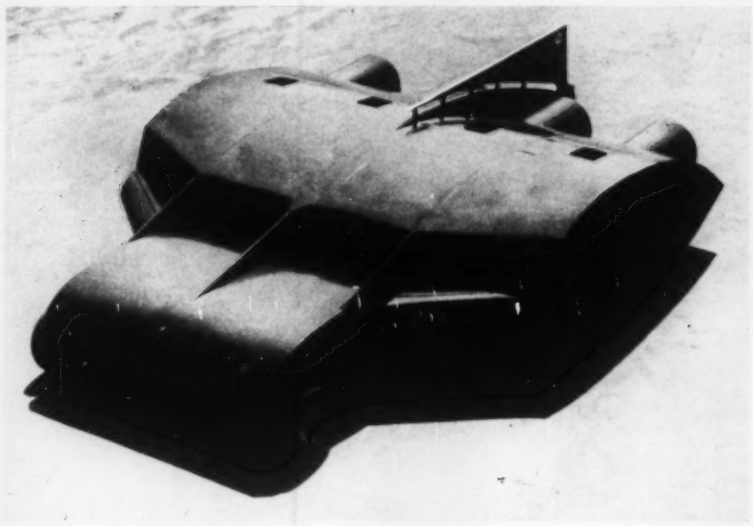
Engineering News Roundup



FOUR-JET HOT-ROD reaches 200 mph, pushing before itself a dead load which it slams into aircraft carrier arresting gear under test. The load represents a jet plane. Four J33-A16 turbojet engines deliver 28,000 lb of thrust, 60 times that of an average automobile. The car follows an I-beam down the center of a 5000-ft track; is slowed by widened I-section while load continues free. Neither driver nor pilot accompany the vehicle. Dead-load car and the jet pusher were developed by All American Engineering Co. for use at the Naval Ship Installations Test Facility, Lakehurst, N. J.

for the superseded weapons, but comparably effective. It is said to be capable of penetrating a steel helmet at 1200 yd.

Adoption of the new rifle rounds out a program for a new small-arms weapons system, long planned and partly consummated recently with the adoption of an M-60 General Purpose Machine Gun. Both the new rifle and the new machine gun fire the 7.62-mm NATO cartridge which will be common to all NATO allies.

The new system offers many advantages. It gives the modern Army a better and lighter rifle and a lighter machine gun to give forward infantry units greater firepower, while cutting the number of weapons in the small-arms system from seven to two (one machine gun and a rifle in the two barrel versions).

The system cuts field logistics loads by reducing the types of small arms ammunition, and, significantly, adopts a cartridge that will be standard also for our allies. It simplifies handling and maintenance problems and reduces training time for the combat soldier.

Meetings

AND EXPOSITIONS

June 23-25—

Alloy Casting Institute. Annual Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from institute headquarters, 32 Third Ave., Mineola, N. Y.

June 24-28—

American Institute of Electrical Engineers. Summer General Meeting to be held at Sheraton-Mt. Royal Hotel, Montreal, P. Q. Further information is available from institute headquarters, 33 W. 39th St., New York 18, N. Y.

August 11-15—

American Society of Mechanical

Circle 425 on page 19→

1,500,000 CYCLE

SUBMARINE TEST

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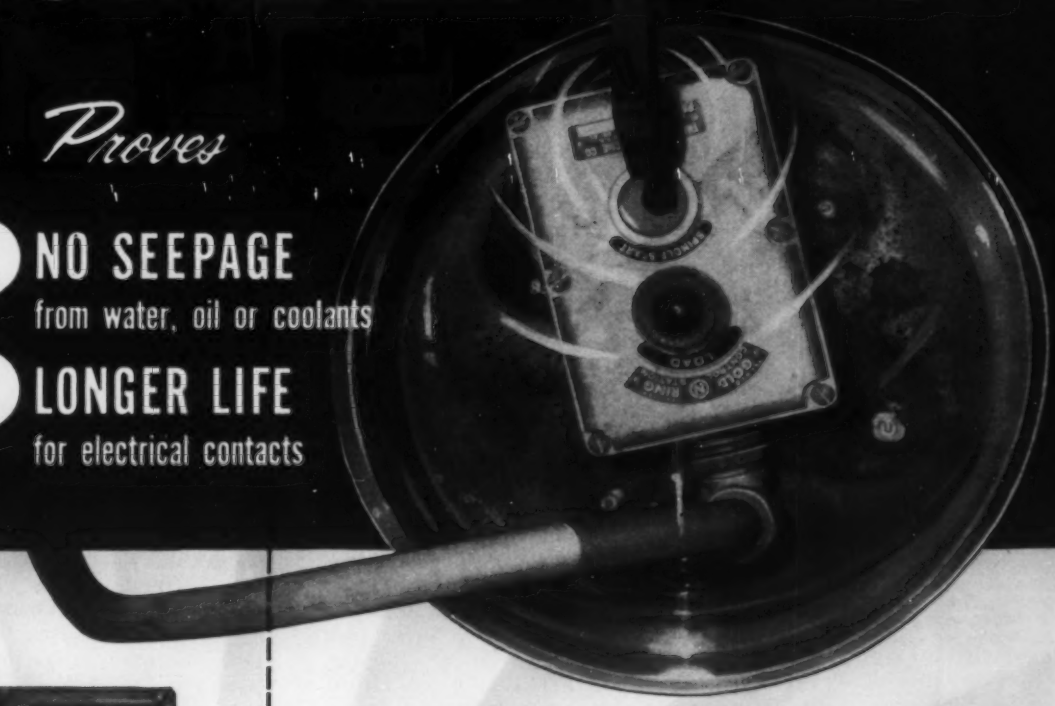
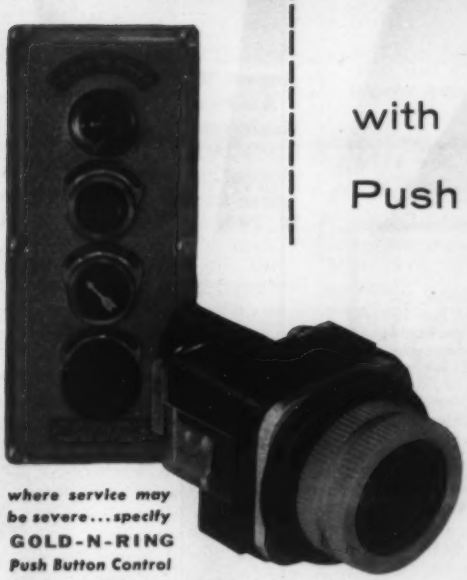
2. **LONGER LIFE** for electrical contacts



with THE NAMCO SEALTIGHT **GOLD N RING** Push Button Control Station Switch



where service may be severe... specify **GOLD-N-RING** *Push Button Control Station Switches... and be sure*

This test simulated conditions much more severe than even the most demanding electrical control service would ever duplicate. Without once "coming up for air," this standard GOLD-N-RING 2-unit control switch was immersed in fluid for more than 338 hours, during which momentary electrical contact was made 1,500,000 times—at the rate of 64 cycles per minute.

This test proved the flexing qualities of the synthetic, oil-resistant diaphragm beyond a doubt. It also pointed up the "staying qualities" of the extra-large, heavy-duty, alloy silver electrical contacts.

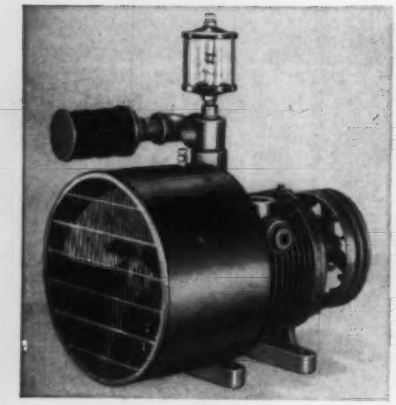
If you are looking for a switch that is designed and built to *keep on performing* long after your machine is installed, you'll find we talk your language.

Ask us to send Catalog ECS-56—or, better yet, ask a representative to call.

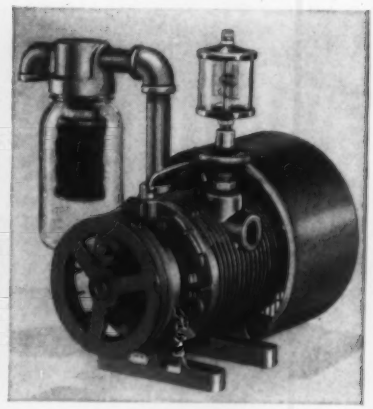
ELECTRICAL MANUFACTURING DIVISION...

National Acme

THE NATIONAL ACME COMPANY • 188 EAST 131ST STREET • CLEVELAND 8, OHIO



Compressor Model 4565-P3 to 20 p.s.i.



Vacuum Pump Model 4565-V6 to 25" hg.

Big NEW 45 c.f.m. fan-cooled Model 4565

GAST rotary vane AIR PUMPS—

Twice the capacity of previous models!

COMPRESSOR

Delivers to 45 c.f.m., to 20 p.s.i.g. continuously with 5 h.p. motor at 1750 r.p.m. At lower pressures, 3 h.p. may be used. Includes automatic lubricator, felt type intake filter.

•

VACUUM PUMP

Delivers to 45 c.f.m., vacuum to 25 in. hg. with 3 h.p., 1750 r.p.m. For 35 c.f.m. at 1350 r.p.m., 2 to 3 h.p. is adequate. Has heavy-duty lubricator and exhaust muffler.

•

WRITE TODAY for Bulletin 557-VP with performance data.

Here's new, bigger-volume air pump utility—for original equipment or plant use! Built for continuous, heavy-duty service as either a Compressor or Vacuum Pump, the Model 4565 eliminates water-cooling headaches. It's air-cooled by a 10" diameter pitch fan enclosed by cowl-guard which directs cooling air and insures safety by covering fan mounted on shaft extension.

Long-lived, efficient 5-vane rotary design delivers a positive displacement of pulseless air. No air tank is needed on compressor.

Pump is easy to mount. Drive with double v-belts eliminates precision alignment problems, and fan on pulley adds extra cooling capacity. Heavy ball bearings, with double row on drive end. Pump weight approximately 92 lbs.

Investigate Gast Model 4565—it may solve a problem for you! **Gast Manufacturing Corp.**, P.O. Box 117-P Benton Harbor, Michigan.

SUGGESTED APPLICATIONS

As volume source of low pressure air or vacuum, independent of plant air lines. COMPRESSOR: For air atomizing No. 5 or 6 fuel oil on burners for packaged boilers to 500 h.p., etc. VACUUM PUMP: Does the work of two smaller pumps for paper or sheet feeding to printing presses, packaging, labeling or bottle-filling machinery. Suitable for pipe-line milking machines, and for vacuum-forming large plastic sheets. Recommended for dry vacuum only.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

News Roundup

Engineers. Heat Transfer Conference to be held at the Pennsylvania State University, University Park, Pa. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N.Y.

August 12-15—

Society of Automotive Engineers. West Coast Meeting to be held at the Olympic Hotel, Seattle. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

August 20-23—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Additional information can be obtained from Wescon headquarters, 342 N. La Brea, Los Angeles 36, Calif.

August 26-28—

Gas Dynamics Symposium to be held at the Technological Institute of Northwestern University. Sponsors are the American Rocket Society and the university. Further information can be obtained from Dr. Ali Bulent Cambel, Gas Dynamics Laboratory, Northwestern University, Evanston, Ill.

August 28-30—

American Institute of Electrical Engineers. Pacific General Meeting to be held in Pasco, Wash. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

"Oh yeah—meant to tell you. That board's kinda loose."

Circle 426 on page 19

Circle 427 on page 19→

It's easier to strike a match on plate glass than on the raceway of a quality ball bearing. The raceway's smoothness makes it virtually impossible. Even so, not all bearing raceways are equally smooth.

Hoover Honed Raceways are super smooth . . . superbly finished

Bearing life—load capacity—quietness. These and other factors in ball bearing performance depend largely on the smoothness and finish of the bearing's raceway.

And that's where *Hoover Honed* Raceways pay off . . . in extra smoothness and finish. All makes of bearing raceways are ground. But Hoover Raceways are also *fully honed*. Hoover Honing, a patented process developed by Hoover, is the last word in precision finishing for raceways.

Coupled with *Hoover Honed* Raceways are matched sets of Hoover *Micro-Velvet* Lapped Balls, made to unusually high standards of smoothness and roundness. Precision throughout the working surfaces achieves superior ball bearing quality . . . assures long life and unexcelled performance.

Investigate Hoover's line of ball bearings in the light, medium and heavy series, available in a variety of types. Hoover engineers are ready to assist manufacturers with engineering and design information. Write Hoover about your problem.

hoover

BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN

Hoover Honed and *Micro-Velvet* are Hoover Trademarks.

HOOVER HINTS:

Common Causes Of Bearing Failure

What makes an anti-friction bearing stop doing its assigned job? Improper lubrication, foreign bodies, soft balls or raceways, poor race concentricity, high operating temperatures and incorrect bearing selection—all are possible causes for premature bearing failure.

Common causes of bearing failure is but one of the many problems confronting users of anti-friction bearings—this problem as well as others pertaining to bearings are given concise coverage in the Hoover Handi-Book of Anti-Friction Bearings. Write for your copy today . . . it's written to help you select the right bearing for any application.

Hoover Ball and Bearing Company, Ann Arbor, Michigan.

Mail my copy of "Hoover Handi-Book of Anti-Friction Bearings."

Name_____

Title_____

Company_____

Address_____

City_____ **State**_____

Roving reporter, half mile under the sea

Exploring at the bottom of a 2000-foot coaxial cable, "Project Fisheye" now roams the ocean depths collecting information for our Navy about sunken vessels, currents, and mysterious undersea life. Its findings are televised to observers on the surface.

Such information from underseas may well prove as valuable to man as the facts radioed from our man-made satellites in outer space.

Like the electronic age itself, this submarine marvel just couldn't work without the best of electrical insulations—the kind CDF is famous for . . . insulations designed and made for outstanding performance under critical conditions.

FOR SPECIFIC INFORMATION on CDF products, see Sweet's, Electronics Buyers' Guide, and other directories. Then send us your print or your problem, and we'll return free samples and technical literature.

CDF MAKES Dilecto Laminated Plastics • Celoron and Polyester-Glass Molded Plastics • Micabond Mica Products • Diamond Vulcanized Fibre • Vulcoid • Flexible Tapes of Teflon*, Silicone, and Micabond • Resin-Impregnated Spiral Tubing • *Complete Fabrication Facilities.*

*duPont trademark for its tetrafluoroethylene resin

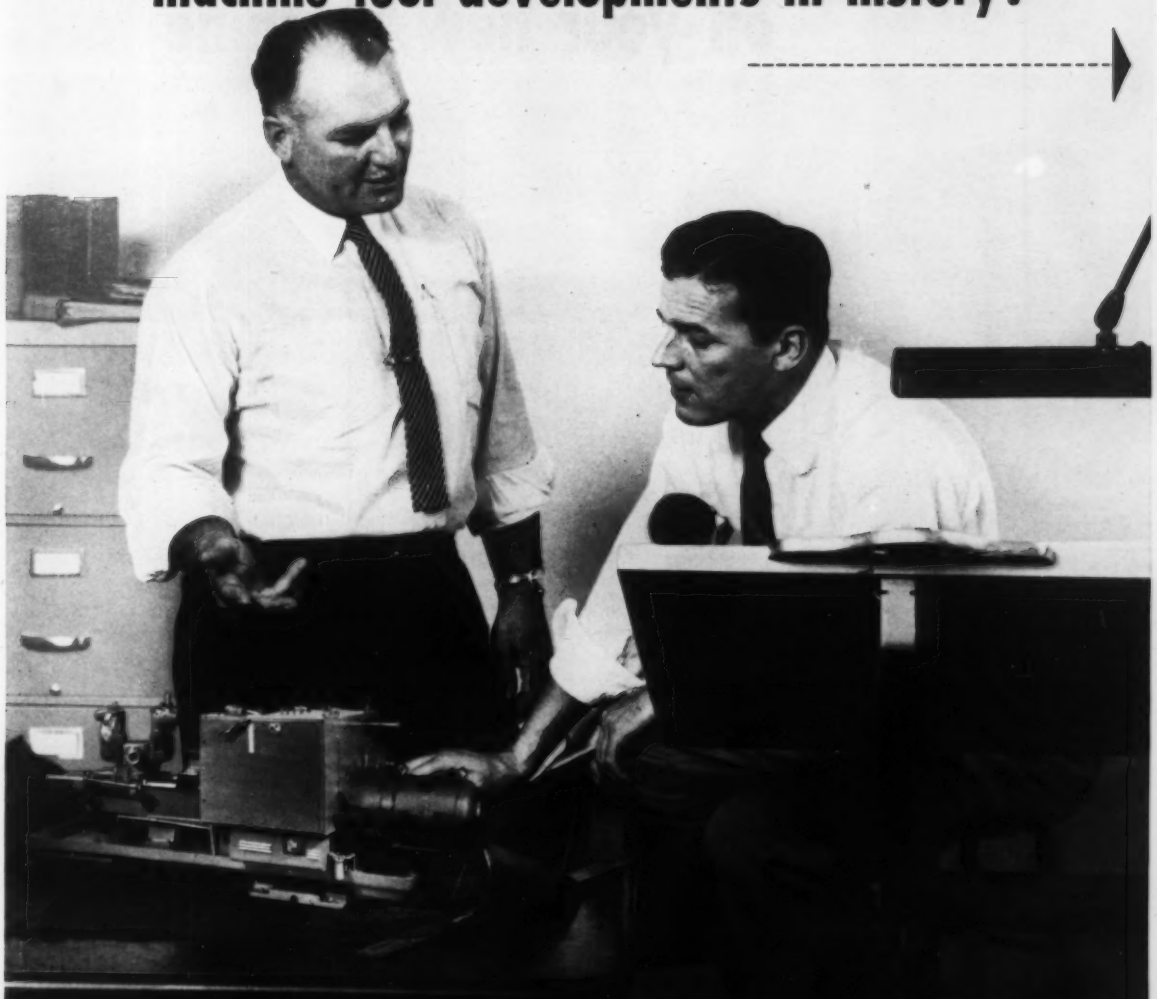
CDF **CONTINENTAL-DIAMOND FIBRE**

A SUBSIDIARY OF THE BUDD COMPANY • NEWARK 23, DELAWARE

Circle 428 on page 19

MACHINE TOOL DESIGNERS:

Westinghouse components and services will help you pioneer the greatest machine tool developments in history!



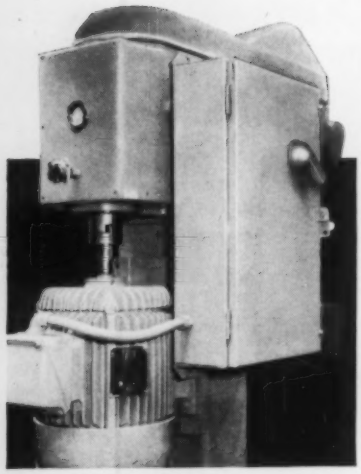
YOU CAN BE SURE... IF IT'S

Westinghouse

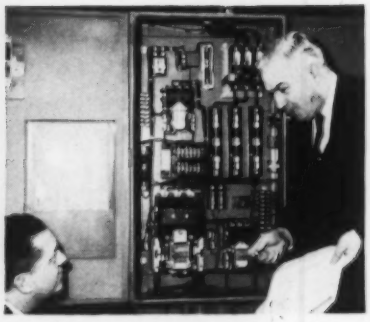
MP-3050-1

NEW DEVELOPMENTS FROM WESTINGHOUSE . . .

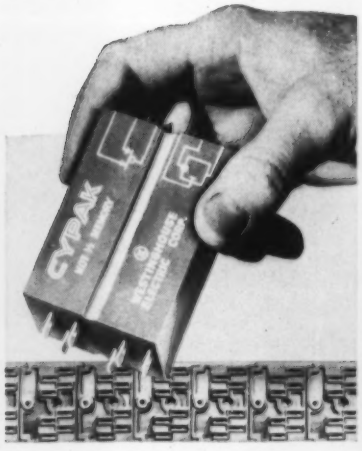
Improve drive and control functions on your new machine tools



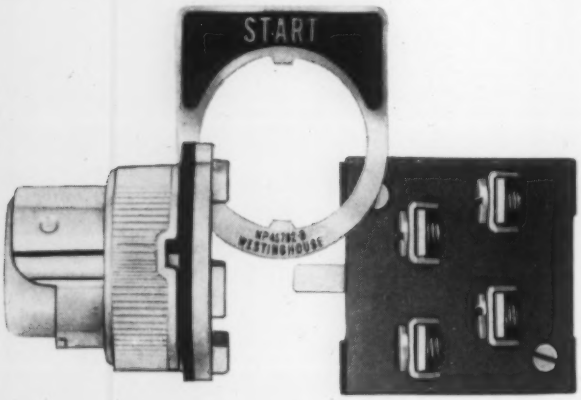
Eighty light-load reversals per minute and no overheating . . . with Westinghouse Life-Line® "A" motors. Reliable performance under severe duty cycles lets you plan greater versatility for machine tools.



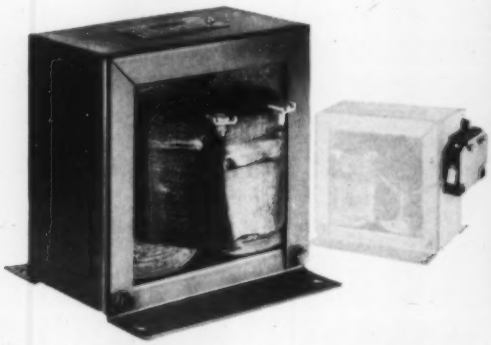
Cushioned start of connected load is assured by Westinghouse magnetic reduced-voltage starters. Add-A-Part feature provides flexibility for design and future change-over.



Cypak control has no moving parts to wear, corrode or jam. Service life is 15 times that of mechanical relays, maintenance and down time virtually eliminated. Cypak systems are compact, light, easy to modify.



Just 38 Westinghouse Oil-Tite* pushbutton components . . . standardized, interchangeable, always available from stock . . . offer up to 1,500,000 pushbutton control arrangements—cut space, inventory needs. *Trade-Mark



Westinghouse machine tool transformers take one-third less space, exceed NEMA regulation standards by 30%. Add-A-Part fuse blocks and breakers extend design selection, reduce transformer inventories.

The growing trend to faster specialized machine tools with more automatic operation makes design of compact, dependable drive and control systems for your products more vital than ever. Westinghouse has recently contributed many significant electrical developments to machinery builders that promise great strides in machine tool progress.

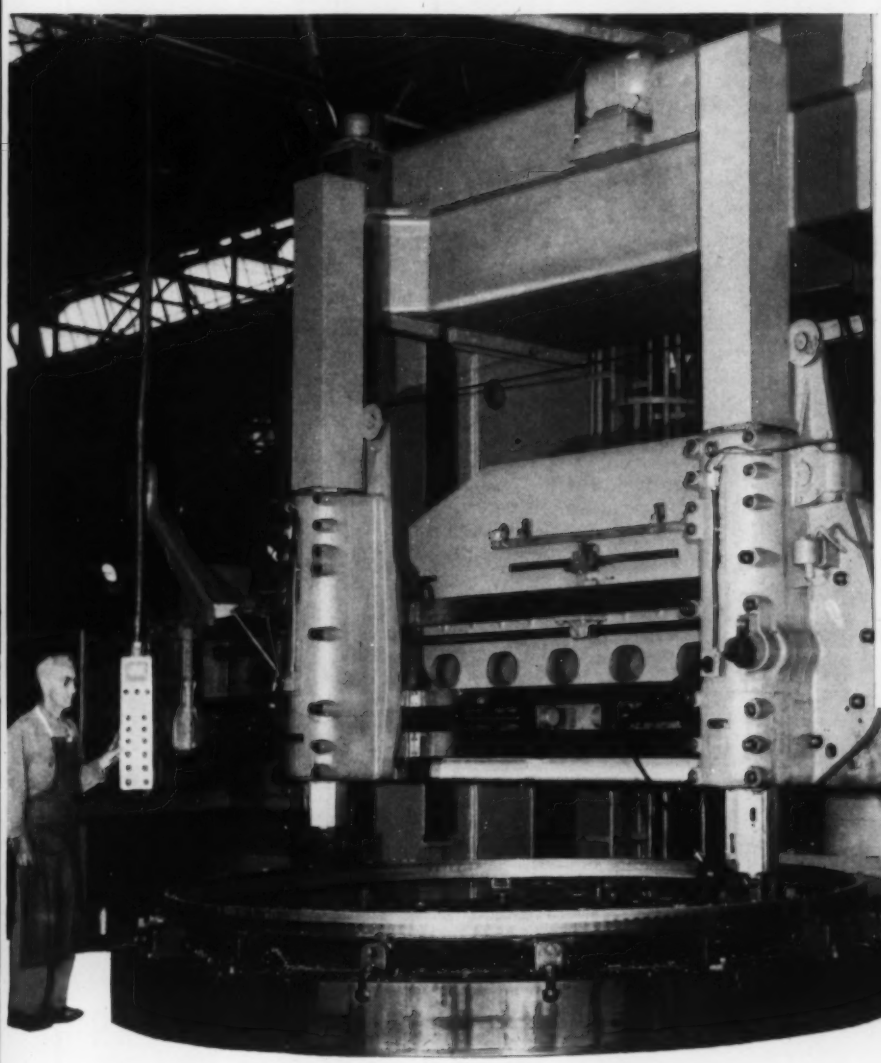
For example, there's Cypak*, a revolutionary development of Westinghouse research for reliable electrical control for machine operations, processes, and coordinated handling of materials. *It has no moving parts* to wear, corrode or jam . . . assuring long life and dependability.

Contactless limit switches, industrial electronic components unsurpassed in performance, improved-design motors, and numerous other product refinements and innovations point to Westinghouse as the electric components supplier for your machine tools.

Developments like these will help you design and build machine tools that better satisfy your customers through increased productivity, reduced inspection and maintenance, and more precise operation. Whatever the function you want performed . . . sensing, transmitting, recording, computing, control, or driving . . . think of Westinghouse components first.

*Trade-Mark
MP-3050-2

YOU CAN BE SURE... IF IT'S Westinghouse



Versatility of Westinghouse AV Drive pays off in applications like this heavy-duty, 14-foot boring mill. Package drive provides on-the-spot conversion of a-c power supply to d-c for precise speed control over a wide, adjustable speed range.

Circle 429 on page 19

Westinghouse service and facilities back up product performance

Your local Westinghouse representative should be a member of your machine design team. He is trained to give you the full benefit of Westinghouse engineering and development information in analyzing your machinery electrification problems.

Westinghouse facilities are located in industrial centers from coast to coast. Westinghouse research . . . field engineering service . . . local manufacturing and repair plants . . . renewal parts stocks . . . all have been established to benefit you and your customers.

The Machine Tool Electrification Forum, sponsored annually by Westinghouse during the past 21 years, is an example of Westinghouse participation and cooperation with the machine tool industry. New ideas fostered and exchanged at such meetings help speed machine tool advances.

When you specify components, choose Westinghouse and be *sure*. You get one-supplier responsibility for products of outstanding quality, backed by more than 70 years of electrical experience. And, Westinghouse components help sell your products. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

MP-3050-3

Westinghouse serves these O. E. M. industries

- Air conditioning
- Appliance
- Communications—electronic
- Electric apparatus
- Fan and blower
- Machine tool
- Materials handling
- Panelboard and switchboard
- Prime mover equipment
- Pump and compressor
- Miscellaneous machinery

. . . with these components

- Motors—gearmotors
- Adjustable-speed drives
- Gearing
- Controls—relays—circuit breakers
- Semiconductors
- Cypak
- Magamp* magnetic amplifiers—rectifiers
- Heating elements—thermostats
- Transformers
- Instruments
- DYNAC® magnetic braking

*Trade-Mark

YOU CAN BE SURE... IF IT'S Westinghouse

Circle 429 on page 19

Circle 430 on page 19→

DOW CORNING CORPORATION

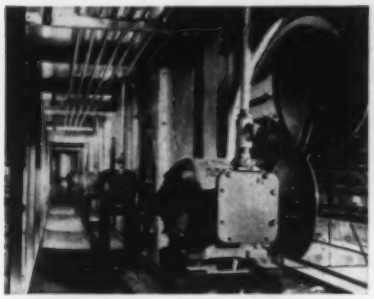
Silicone News

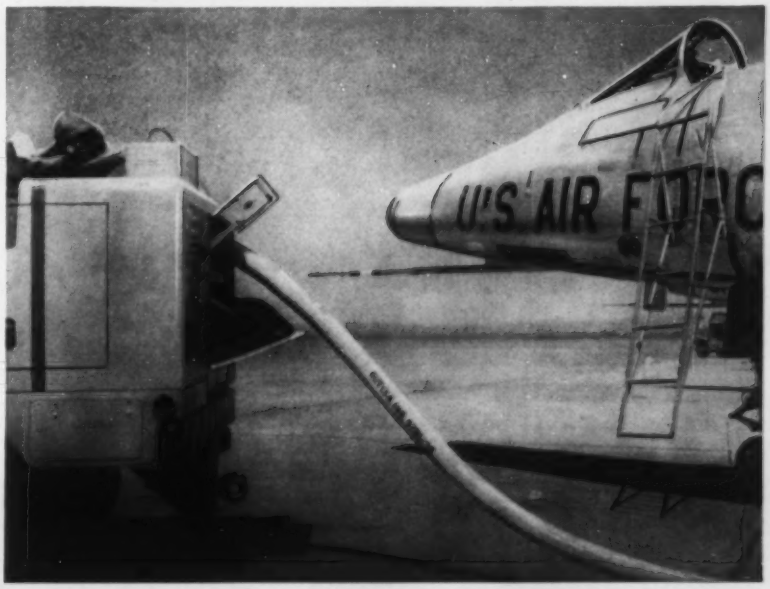
FOR DESIGN ENGINEERS No. 39

Silicone Insulated Motors Provide Dependable Service in Oven Heat

Even the hot, humid, acid atmosphere of a lumber drying kiln won't ruin fan motors insulated with Dow Corning Silicones. Just how tough conditions are for a motor inside a kiln is revealed by Standard Dry Kiln Company, Indianapolis, Indiana.

Not only must Standard's fan motors operate 24 hours a day in ambient temperatures ranging from 200 to 220 F, but they must be able to withstand relative humidity up to 100% and acid atmospheres. No wonder Standard engineers have always been quick to adopt new improvements in motor insulation, and standardized completely on Dow Corning silicone insulation for all Louis Allis fan motors in 1952. (Cont. Pg. 2)





SILASTIC HOSE CARRIES "FURNACE HOT" AIR TO START AIRCRAFT JET ENGINES

Most designers know that jet engines are started by hot air from portable generators. But have you ever given thought to the resilient hose or ducting used to carry the "furnace hot" air from the generator to the engine?

The combination of heat, pressure and rough usage quickly ruins even the strongest metal and fabric hoses. But that's not the case with a new silicone rubber-polyester fiber hose developed by Quaker Rubber of Philadelphia.

Light, tough and flexible, the Quaker hose easily meets rugged service requirements.

TYPICAL PROPERTIES OF SILASTIC FOR HOSE, DUCTS AND TUBING

- Temperature range, °F ..... —130 to 500
- Corrosion ..... Non-corrosive to metal
- Pressure range ..... Low pressure
- Oil resistance ..... Dependent on type of oil
- Light Weight • Weather resistant • Flexible

For example, in recent wear tests a typical production hose withstood 65 psi pressure while conveying 125 pounds of 425 F air per minute for 200 hours on a schedule of three hours on and one hour off. The same hose was coiled and uncoiled 300 times at —65 F, then dragged six miles over concrete, macadam and dirt without noticeable wear! (Cont. Pg. 2)

BOOST INSULATION RESISTANCE WITH SILICONE FLUID

Because Dow Corning 200 silicone fluid has better electrical resistance than wax at elevated temperatures, many designers specify this high temperature liquid dielectric to increase the life and reliability of capacitors, small transformers and many other electronic assemblies.

Gudeman Company of Chicago, for example, impregnate their special line of miniature tubular paper capacitors for filter, bypass and blocking service with Dow Corning 200 Fluid.

Only about half as big as comparable conventional units, these silicone-impregnated capacitors are designed to meet all the electrical and environmental requirements for Characteristic "K", MIL-C-25A.

While the insulation resistance of comparable wax-impregnated capacitors at 85 C (185 F) is only about 15 megohm-microfarads, the new silicone fluid impregnated units register 150 megohm-microfarads at the same temperature. That's approximately 10 times the insulating efficiency of conventional units. *No. 396*

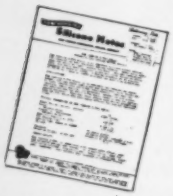
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Silastic — in mechanical applications — increases life and serviceability of original equipment; reduces maintenance and downtime. A completely new brochure gives properties and cites applications and case histories to help you use this versatile silicone rubber to best advantage in your application. *No. 400*

Solventless Silicone Impregnating Resins now commercially available for electrical and electronic equipment, are free-flowing, can be blended, and have good pot life. On curing, these silicone encapsulating resins set to a solid mass having good electrical and physical properties; and retain such properties that a service life of 10 years at 400 F is indicated. *No. 401*

Silastic 916, the first silicone rubber available that combines high strength with thermal stability, is serviceable from —130 to 500 F, has good electrical properties, and is easy to compound and process. *No. 402*

Silicone Coatings for Paper impart excellent, long lasting release characteristics. Applicable as single or two side coatings to glassine, parchment and kraft, they effectively release such sticky materials as asphalt, raw rubbers, epoxy resins and polyurethane foams even after long time contact. Silicone coated papers are useful in wrapping, and interleaving and in making multi-wall bags, cartons and drums. *No. 403*

"Rubber From Rock," a new color-sound movie, explains how Silastic, the Dow Corning silicone rubber, is manufactured from quartzite. Demonstrates why parts fabricated from Silastic retain rubber-like properties from —130 to over 500 F in a wide variety of military and industrial applications. Also covers uses for Silastic as a dielectric in electronic and electrical equipment. To arrange for a showing of "Rubber From Rock" in your plant, circle ---------- *No. 404*

1957 Guide to Dow Corning Silicones is a twelve page, fact-filled reference describing the silicone products of interest to most industries. Containing latest data and information, the new 1957 Guide is designed expressly to help you enjoy the advantages, profits, and savings made possible through imaginative use of these versatile engineering materials. *No. 405*

FOR LASTING BEAUTY AND MAXIMUM PROTECTION AT LOWEST COST . . . USE SILICONE BASED PAINTS

In addition to providing Preway, Inc. of Wisconsin Rapids with a permanently attractive finish for their new line of space heaters, a silicone based paint has solved what could have been a costly design and production problem. Here's how:

When tests on the new Preway heater design revealed that the upper grill often attained a surface temperature of 550 F, it was evident that if coated with an organic finish the grille would have to be raised and the cabinet made larger. Instead of re-designing the cabinet, however, Preway engineers simply switched to a heat and oxidation-resistant silicone paint . . . and the problem was solved.

The silicone finish proved far more durable, as attractive as a conventional enamel and it saved the company the cost of expensive retooling. Furthermore, by keeping the unit compact the silicone finish has helped hold production costs down while saving floor space for the consumer without sacrificing heat output.

Preway also realizes another substantial saving on each unit by applying a silicone-aluminum coating to both sides of the drum-like "heat economizer" inside the heater. By raising the "scaling" temperature of mild steel from 1225 F to 1325 F, the silicone coating permits the use of mild steel in place of stainless . . . an additional saving of $1.59 per unit.

Both of the silicone paints in this application are "Sicon" finishes formulated with Dow Corning Silicones by Midland Industrial Finishes. *No. 397*

SILICONE INSULATED MOTORS *(Cont.)*

By switching to Dow Corning 44 Grease, Standard has also reduced its relubrication schedule for bearings in these motors from once every three months to once every three years.

Still another reduction in costs has been obtained by installing aluminum sheathed motor lead wire covered with Silastic*, the Dow Corning silicone rubber. Not only has the Silastic-insulated cable proved more dependable and maintenance-free than conventional cable, but it costs much less to install and eliminates the need for conduit and fittings.

How does Standard sum up its experience with Dow Corning Silicones after five years? According to J. B. Welch, President, "our experience indicates these motors and their wiring will operate inside the kiln day and night, year 'round without fail." *No. 398*

"HOT AIR" HOSE *(Cont.)*

This rugged new hose is comprised of two inner layers of Silastic*, the Dow Corning silicone rubber, covered with closely woven Dacron. Already a standard accessory for the portable jet "starters," it is now being considered for the hot-air ductwork to operate entire aircraft accessory systems by pneumatics. *No. 399*

*T.M. REG. U.S. PAT. OFF.

Dow Corning Corporation, Dept. 6818, Midland, Michigan

Please send me: 396 397 398 399 400 401 402 403 404 405

NAME _____

TITLE _____

COMPANY _____

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SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION
MIDLAND MICHIGAN

first in silicones

DOW CORNING SILICONES

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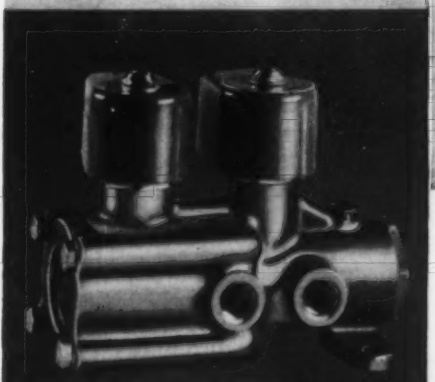
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD. LONDON FRANCE: ST. GOBAIN, PARIS

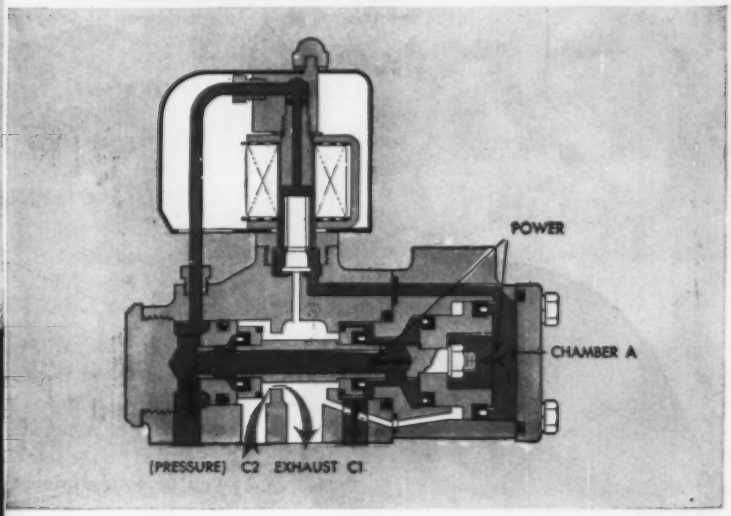
Now available: full line of ASCO 4-way solenoid valves

Single Solenoid: operates when solenoid is energized; returns automatically when de-energized.



Dual Solenoid: operates when either solenoid is energized; will not return until opposite solenoid is energized. Solenoids may be energized continuously or momentarily.

J.I.C. Construction: single and dual solenoids, with sub-plate mounting.



power driven in both directions by line pressure

Now available in ⅜" through 1" sizes, these valves are positive in action. When the solenoid is de-energized, *line pressure* applied to the top of the pilot core forces it off the seat, eliminating possible sticking caused by residual magnetism. *Line pressure* is applied to Chamber A, moving the piston-disc assembly to the left. When the solenoid is energized, Chamber A is exhausted and *line pressure* drives the piston to the right.

absolutely tight seating — no leakage

Combination of metal to metal and resilient seating provides dead tight shut-off — even on air. No grinding, lapping or close adjustments are necessary.

Available in standard, watertight or explosion-proof solenoid enclosures, the Bulletin 8344 permits cycling rates to 850 per minute — mounted in any position. Design simplicity eliminates maintenance problems.

J.I.C. construction available

These 4 way valves are available in all sizes to meet J.I.C. (Joint Industry Conference) standards. Valves are provided with sub-plates, vapor-proof solenoid enclosures, and manual overrides, and are electrically inoperative when the cover is removed.

New ASCO Condensed Valve Catalog No. 201 is now available. Write today for this basic reference on solenoid valves.

AUTOMATIC TRANSFER SWITCHES
SOLENOID VALVES ELECTROMAGNETIC CONTROL

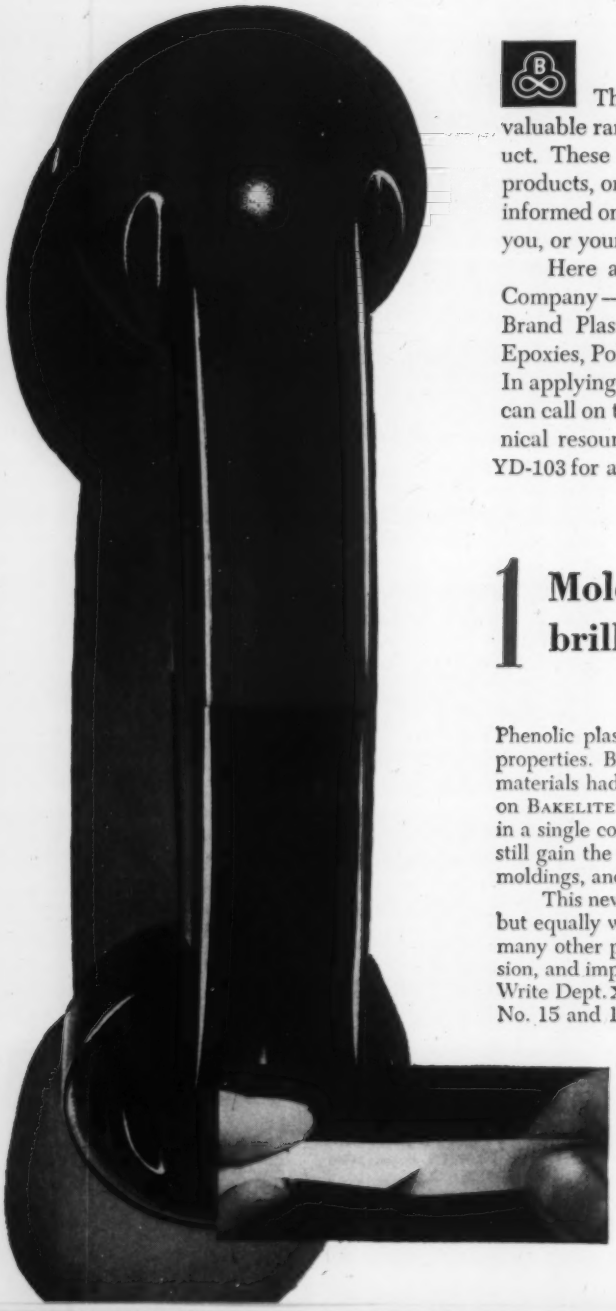
Automatic Switch Co.
54-A Hanover Road, Florham Park, N. J. FRontier 7-4600

ASCO

Circle 431 on page 19

Designing with BAKELITE Plastics

- *Colorful new coating needs no primer*
- *Flexural strength of vinyl hinges*
- *Durability plus chemical resistance*



The variety of BAKELITE plastics and resins gives you a valuable range of properties to work with in designing your product. These features can often lead the way to ideas for new products, or to new improvements. So it's shrewd planning to keep informed on the latest developments in plastics—to be sure of what you, or your competition, might put to good use.

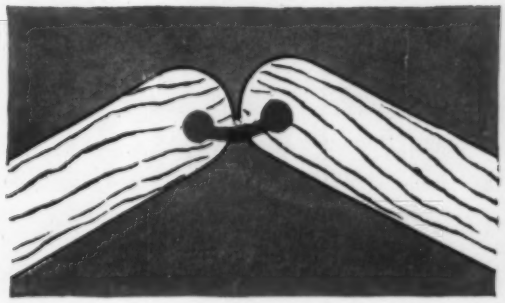
Here are some applications of materials made by Bakelite Company—a leader in the plastics field for 46 years. BAKELITE Brand Plastics and Resins include Phenolics, Styrenes, Vinyls, Epoxies, Polyesters, Polyethylenes, Silicones, and Impact Styrenes. In applying these modern materials to your own requirements, you can call on the extensive experience, laboratory facilities, and technical resources of Bakelite Company. Send full details to Dept. YD-103 for a thorough evaluation of your problem.

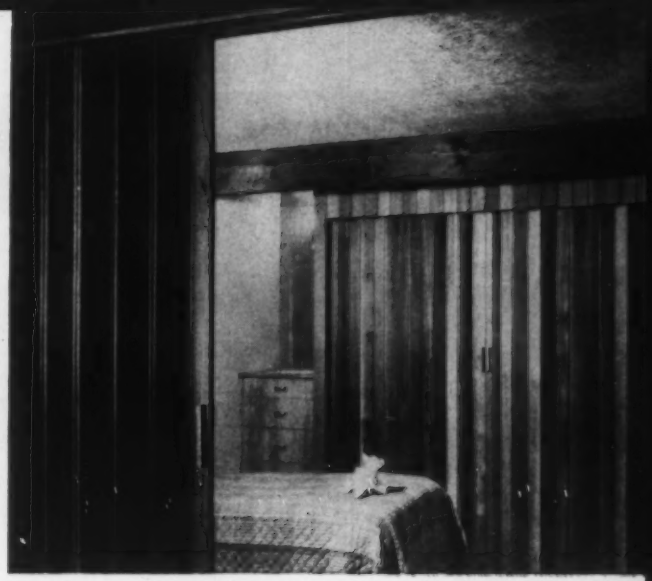
1 Molded phenolics get brilliant color at low lost

Phenolic plastics have long been noted for their economy and useful properties. But when bright color in broad range was needed, other materials had to be used . . . at higher cost. Now, a new coating based on BAKELITE Brand Epoxy Resins provides excellent hiding properties in a single coat. It adheres well with no primer required. Thus, you can still gain the production economy and quality performance of phenolic moldings, and have any hue of the rainbow as well.

This new enamel adheres not only to the glossiest phenolic surface, but equally well to steel, tin, brass, copper, aluminum, glass, wood, and many other plastics. It has excellent resistance to heat, corrosion, abrasion, and impact . . . can be high-gloss or flat in a wide variety of colors. Write Dept. XS-103 for copies of BAKELITE Coatings Technical Releases No. 15 and 16 for a description of epoxies for coatings.

See the difference . . . both black and brown phenolic molded articles can be given new color in a single coat without a primer. Adhesion test (inset) shows a coated copper strip cut with scissors and twisted vigorously. Finish does not crack or peel away from the base material.





2 Strong, silent hinges for folding doors are extruded from elastomeric vinyl plastic

Full-length, one-piece hinges extruded from BAKELITE Brand Elastomeric Vinyl Plastic connect the panels of these folding doors. The manufacturer put them through 250,000 opening and closing cycles. They operated with friction-free smoothness; no squeaks, and no failures. The tough vinyl strips don't tear while being inserted, even though they are pulled through undercut grooves in the panel edges and their H-shaped cross section is formed for a tight fit. In addition, their flexing area is precisely the right thickness for proper functioning.

Another advantage of vinyls is resistance to household cleaning materials, waxes, paints, varnishes, and lacquers. Their color variety permits hinges to harmonize with the panel woods. For further information, write Dept. XT-103.

3 Tough, chemical-resistant C-11 plastic helps improve battery design

A frame molded of BAKELITE Brand C-11 Plastic forms the open top of the "EVEREADY" CG-500 railroad signal cell—an air-depolarized cell. It also holds the carbon-grid cathodes, exposing their inside surface to freely-circulating air, and supports the zinc-plate anodes. The whole assembly is suspended in a jar of 30 per cent potassium hydroxide liquid electrolyte. Operating temperatures can range from minus 20 to plus 80 deg. C.

The combination of properties found in C-11—mechanical strength, molding accuracy, dimensional stability, and chemical resistance—may be just what your designs call for. Versatile C-11 Plastic also matches industrial applications like this with benefits in the packaging and housewares fields, where it offers color, transparency, and resistance to attack by many food chemicals. For details, write Dept. XU-103 and ask for "Molding News," Vol. I, No. 4.

BAKELITE BRAND
PLASTICS

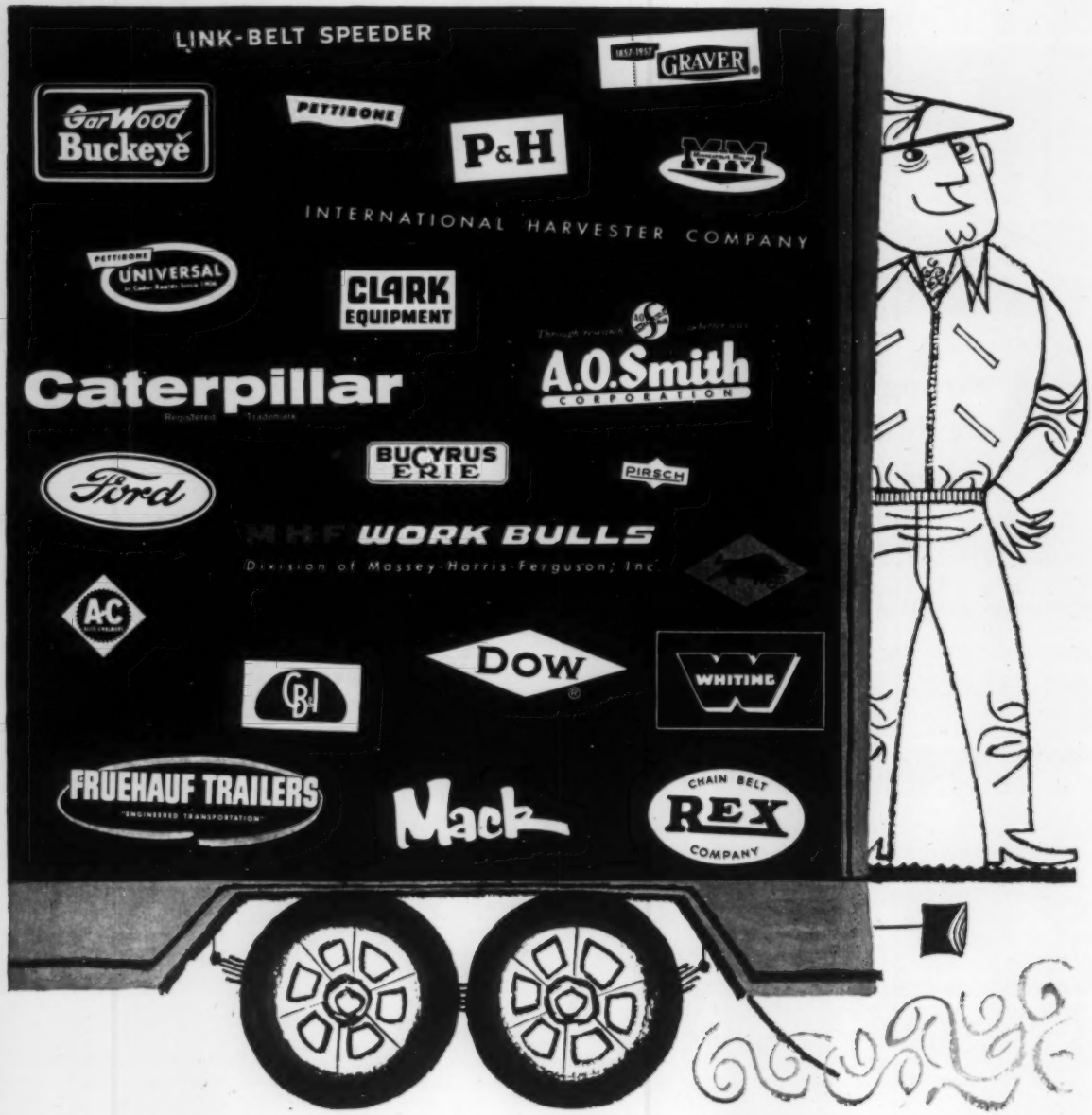
POLYESTERS • EPOXIES
PHENOLICS
IMPACT STYRENES
STYRENES • VINYLS
POLYETHYLENES • SILICONES

UNION CARBIDE

BAKELITE COMPANY, *Division of Union Carbide Corporation* UCC 30 East 42nd Street, New York 17, N.Y.

The terms BAKELITE, EVEREADY, UNION CARBIDE and the Trefoil Symbol are registered trade-marks of UCC.

Circle 432 on page 19



Wherever feet or wheels must go . . . America's leading companies look to Inland 4-WAY® Safety Plate

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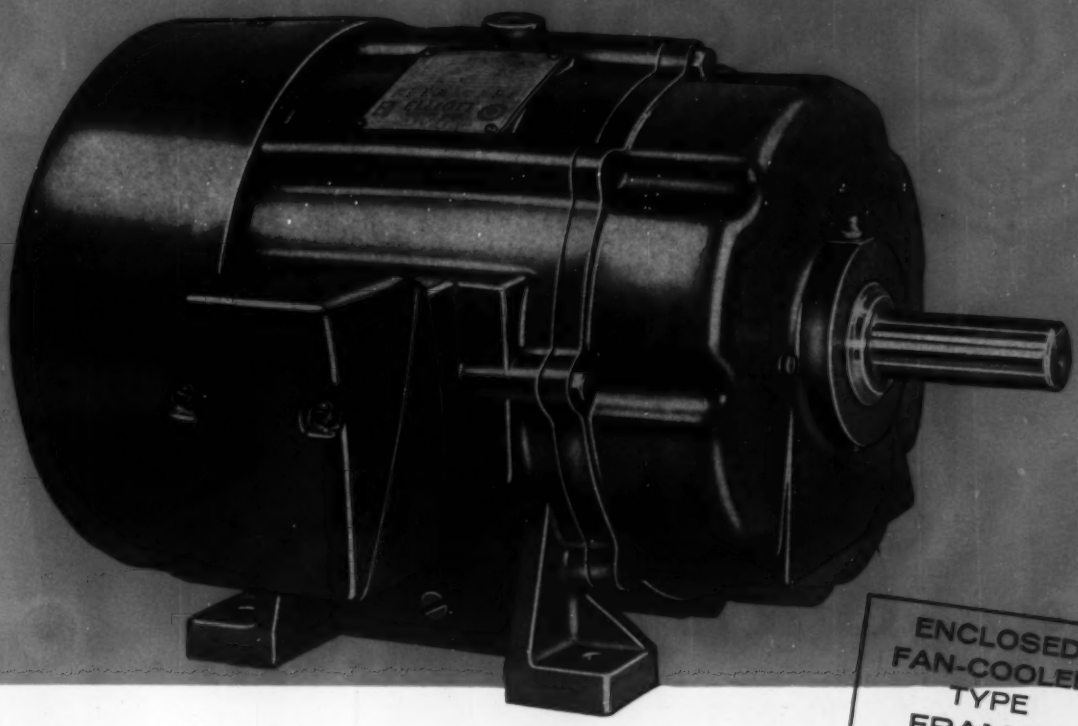
INLAND STEEL COMPANY
38 South Dearborn Street • Chicago 3, Illinois
Sales Offices: Chicago • Milwaukee • St. Paul • Davenport
St. Louis • Kansas City • Indianapolis • Detroit • New York

Circle 433 on page 19

Inside and Outside . . . entirely new



ENCLOSED FAN-COOLED TYPE FRAMES 184-256U

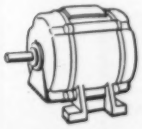
Elliott C-W Type N Motors

NEW PERFORMANCE! You get more horsepower per pound from these compact Elliott C-W motors because of their improved design, and the use of vastly superior insulating materials and electrical steels. Due to greater mechanical and dielectric strength, insulating materials occupy less space. More space is available for copper—the "muscle" of the motor.

NEW PROTECTION! Internal parts of Elliott C-W motors are completely protected by rugged housings — dripproof, or totally-enclosed, as required. Efficient fans assure ample cooling.

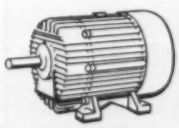
NEW DEPENDABILITY! New Elliott C-W type N motors are designed for the utmost in dependability. They will withstand physical abuse. Use of highly dependable insulating materials assures prolonged life; anti-friction bearings are available in several optional types, to meet severe service conditions.

OTHER C-W TYPE N MOTOR ENCLOSURES



Totally-enclosed non-ventilated

Dripproof Protected



Totally-enclosed, fan-cooled (ribbed frame)

ELLIOTT Company

CROCKER-WHEELER DIVISION

WRITE for new bulletin describing Elliott C-W Type N Motors. Address: Elliott Company, Crocker-Wheeler Division, Jeannette, Pa.

W8-4

Circle 434 on page 19

7 *ways to better whiteprints...*

on the new printmaster 810

Here's the brand new Printmaster 810—with 7 big new operating features. They make your printmaking easier, more fool-proof than ever before!

1. New air flow system for better print pickoff
2. New diaphragm ammonia pump for top uniformity in developing
3. New cartridge heater for greatly improved development at high speeds
4. New phenolic "fingers" to pick off tracings without tearing
5. New protection sheet and suction baffles to keep originals safe
6. New feeder brushes to flatten curl in rolled tracings
7. New tracing receiving system to handle cut sheets and rolled tracings, both!

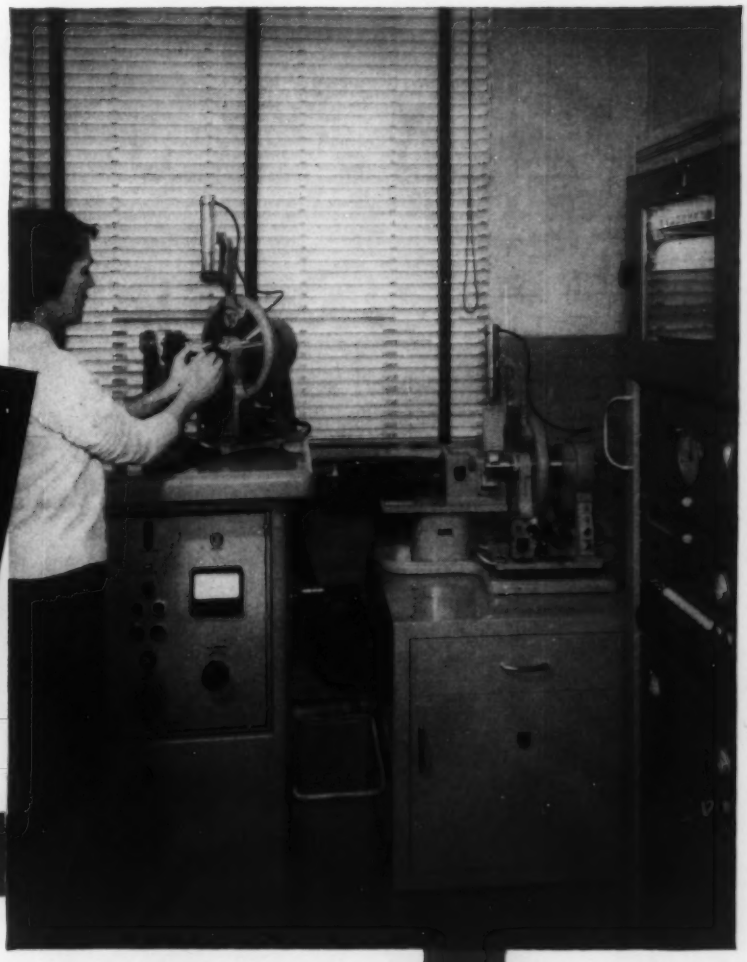
And that's not all. Incorporated into the "810" are such *proven* Ozalid advances as the electronic drive . . . low temperature cooling system . . . exclusive blower-timer and U/L approved safety devices. *Why not test run your own tracings through the new "810"? Simply call your local Ozalid representative. His number's in the phone book, or write: Ozalid, Dept. GG-6, Johnson City, N. Y.*

A Division of
General Aniline &
Film Corporation.
In Canada:
Hughes Owens Company Ltd.,
Montreal

OZALID®

First name in whiteprinting

Circle 435 on page 19



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SOCKET SCREWS
THE H-K WAY—

X-RAY UNITS PERFORM A COMPLETE AND ACCURATE METAL ANALYSIS

We know it's safe to guarantee unfailing performance for all H-K products!

For the finest in socket screw products . . . for unmatched SAME-DAY SERVICE—the name to remember is Holo-Krome. Write for free catalog and technical information.

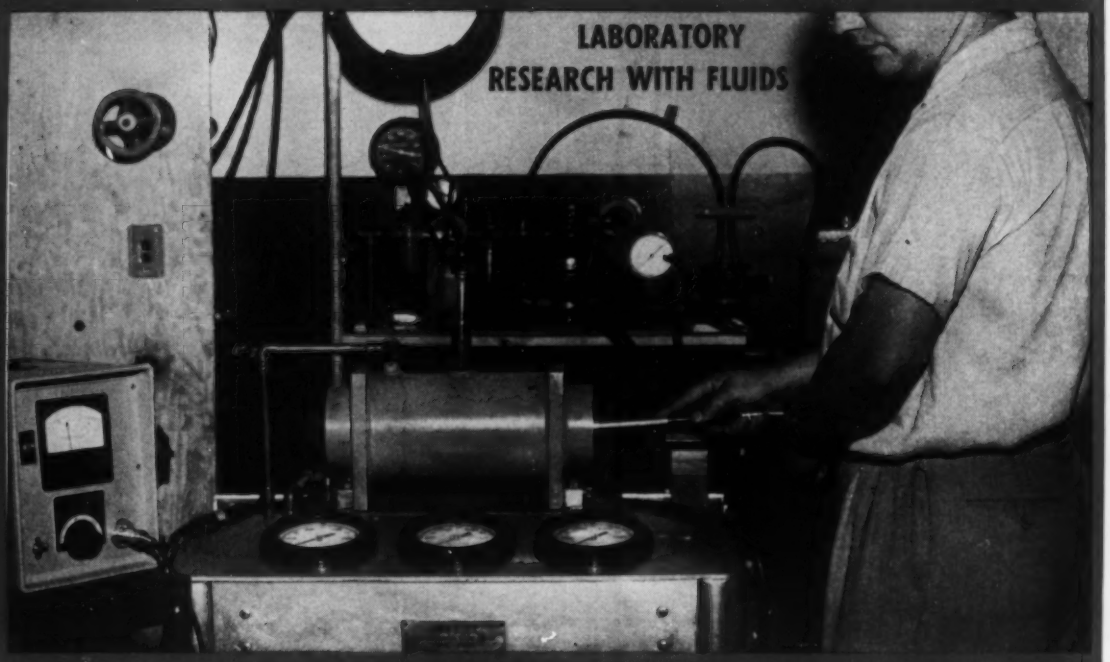
HOLO-KROME SOCKET SCREWS

Sold Only Through Authorized Holo-Krome Distributors

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

Circle 436 on page 19

Complete Line of

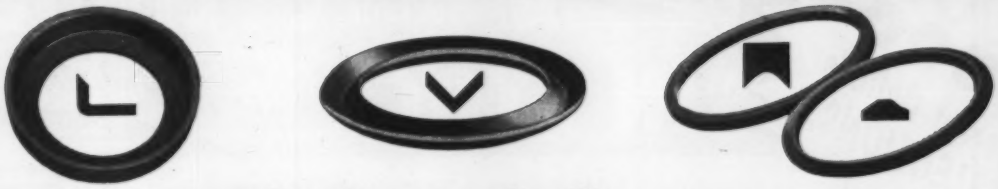


HOUGHTON'S Background in Packings &

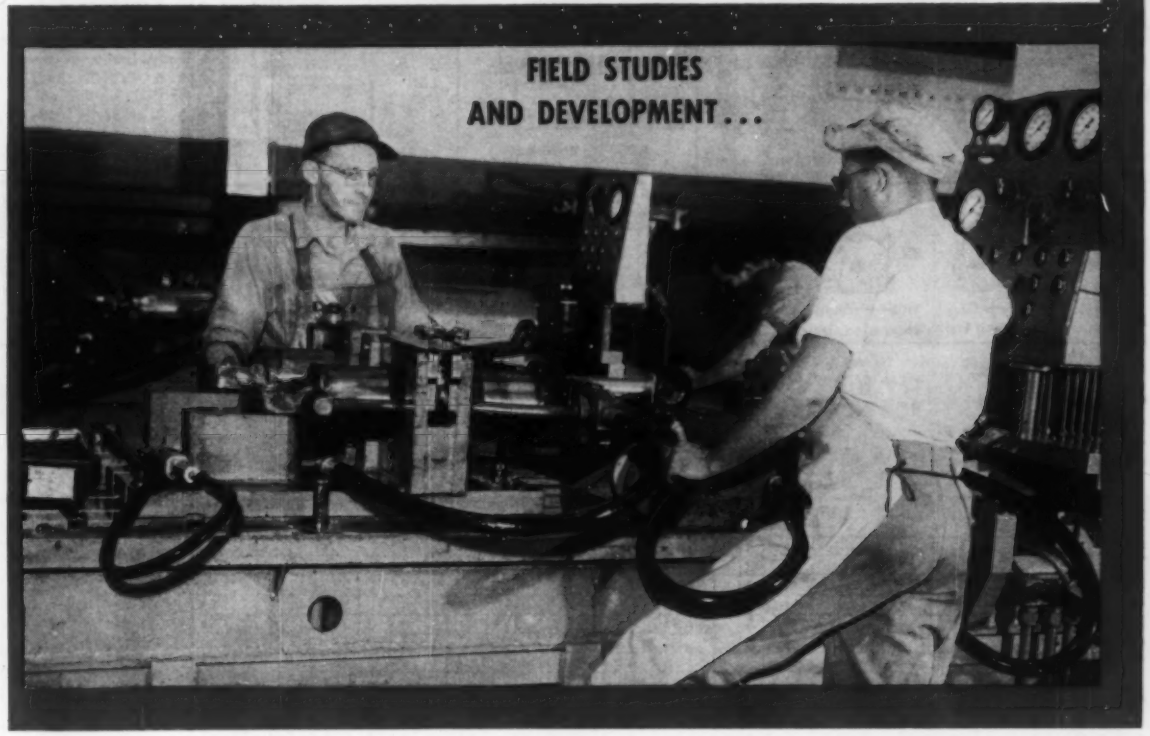
Years of hydraulic experience have earned for Houghton a position of leadership in both packings and fluids on which you are invited to cash in.

From this one source, you can get a complete range of sizes in cups, "V's", "U's" and "O" rings in wax impregnated leather, rubber impregnated leather, fabricated rubber and homogeneous rubber. In the field of packings, Houghton's know-how is proven by their leadership in standardization; in unique standard stack height for rubber, fabricated and leather "V's"; in the development of the only thoroughly rubber impregnated leather packings; and the advanced "square shoulder and flare" design of cup packings.

Houghton can also give you the advantages of its leadership in hydraulic fluids. In this field, Houghton was the first to develop a petroleum hydraulic oil specifically fortified to meet the



Types and Materials...



Fluids means Better Hydraulic Products

requirements of hydraulic operation; Houghton pioneered in the development of fire-resistant hydraulic fluids—equipping every U.S. aircraft carrier with fire-resistant Houghto-Safe.

Don't fail to take advantage of Houghton's background in packings and fluids for your application.

products of...

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Circle 437 on page 19

over 14,000 Different Cylinder SELECTIONS

Miller

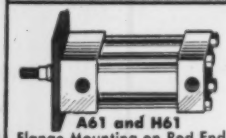
AIR AND HYDRAULIC

"STANDARDIZED" CYLINDERS

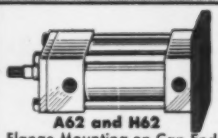
"IN STOCK" for immediate delivery...

See Miller Bulletins A-105 (Air) and H-104 (Hydraulic) for Complete Dimensions and Engineering Data on these standardized "in stock" sizes and other Custom Miller Cylinders in bores up to 20" and strokes up to 22 ft.

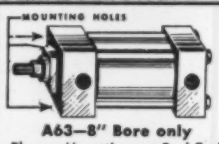
"IN-STOCK" MODELS "A" Signifies Miller 200 psi Air Cylinders; "H", 2000 psi Hydraulic Cylinders. Interchangeable Mountings Are Shown In Red On Drawings.



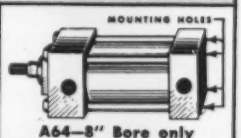
A61 and H61
Flange Mounting on Rod End
(A61 not available in 8" bore)



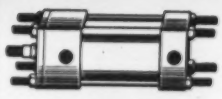
A62 and H62
Flange Mounting on Cap End
(A62 not available in 8" bore)



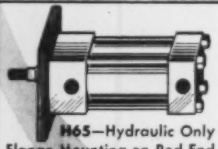
A63—8" Bore only
Flange Mounting on Rod End



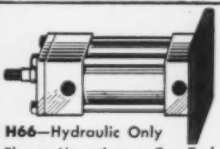
A64—8" Bore only
Flange Mounting on Cap End



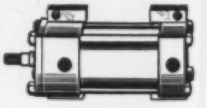
A50 & H50—Tie Rods not extended beyond nuts.
A51 & H51—Tie Rods extended both ends (shown).
A52 & H52—Tie Rods extended. Cap End only.
A53 & H53—Tie Rods Extended. Rod End only.
A54 & H54—Two Tie Rods extended at both ends.



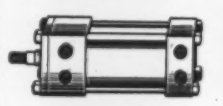
H65—Hydraulic Only
Flange Mounting on Rod End



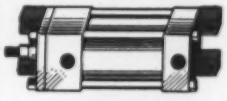
H66—Hydraulic Only
Flange Mounting on Cap End



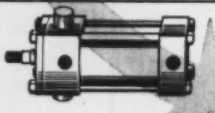
A72 and H72
Side Lug Mounting



A74 and H74
Side Flush Mounting

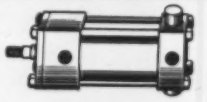


A77 and H77
Side or Foot Mounting

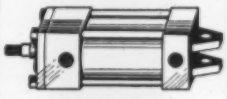


A81 and H81 Trunnion Mounting on Rod End

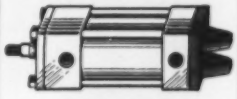
Your Choice of
CAP END CUSHIONED
ROD END CUSHIONED
or
BOTH ENDS CUSHIONED
on all cushioned strokes of all bores shown.



A82 and H82 Trunnion Mounting on Cap End



A84 and H84
Pivot Mounting



A86 and H86
Pivot Mounting

IN STOCK BORES in Inches

"IN-STOCK" STROKES (in Inches)

	BORES	ROD DIA.	ROD TURN DOWN & THREADS		STROKES
AIR	1½	⅝"	7/16-20	Cushioned	3 4 5 6 7 8 9 10 11 12
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12
	2	⅝"	7/16-20	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	2½	⅝"	7/16-20	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	3¼	1"	¾-16	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	4	1"	¾-16	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	5	1"	¾-16	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	6	1⅜"	1-14	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	8	1⅜"	1-14	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
HYDRAULIC	1½	⅝"	7/16-20	Cushioned	3 4 5 6 7 8 9 10 11 12
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12
	2	1"	¾-16	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	2½	1"	¾-16	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	3¼	1⅜"	1-14	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	4	1¾"	1¼-12	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
	5	2"	1½-12	Cushioned	3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36
				Non-Cush.	1 2 3 4 5 6 7 8 9 10 11 12 14 16 18 20 22 24 28 32 36

(4) (3)

① "A" and "H" Models 82, 84 and 86 with strokes over 18" require stop tubes.

Column strength requires larger diameter piston rods for the following:

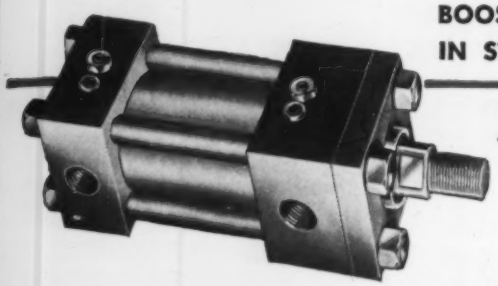
Air Cylinder Models A82, 84, and 86 with strokes inside area (1), when operated at 100 psi and over;

All hydraulic models with strokes inside area (2) and Models H82, 84, and 86 with strokes in area (4), when operated at 2000 psi and over;

Models H82, 84 and 86 with strokes inside area (3), when operated at 1000 psi and over.

Depending upon Trunnion Pin location, "A" and "H" Models 83 with standard diameter piston rods can have longer strokes than Models 82, 84 and 86.

See Miller File #251 for oversize piston rod and stop tube requirements.



BOOSTERS IN STOCK

Immediate Delivery on the following Miller 25 to 1 Ratio Boosters (80 psi air input produces 2000 psi hydraulic oil output): Model B4, 5" bore, 1" dia. ram, 6" and 12" strokes; Reciprocating Booster Model DA77-RBA8, 5" bore, 1" dia. ram, 6" stroke. Also Booster Tanks, 5" dia., 6" and 10" heights.

Write For Catalog and Stock Price List

Miller

Miller FLUID POWER DIVISION
Flick-Reedy Corp

2006 N. Hawthorne Ave. • Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

Circle 438 on page 19

Always, at SKF, you will receive unbiased advice

because

– All four basic types of anti-friction bearings are available from **SKF.**

because

– They offer an extraordinarily wide range of sizes and combinations to meet virtually any requirement.

because

– Their long experience in the widest variety of bearing applications is your assurance of receiving sound recommendations.

because

– Thousands of manufacturers have been using the **SKF** Bearing Advisory Service for many years – always with good results. This dependable service is available to you, too. 7784

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EVERY TYPE—EVERY USE

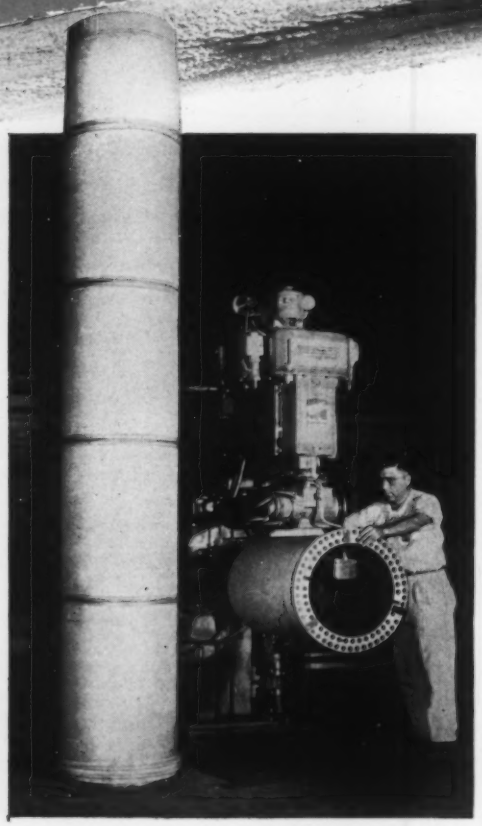
- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings ("Tyson")*

* Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

HEAT • WEAR • CORROSION

HAYNES Alloys solve the

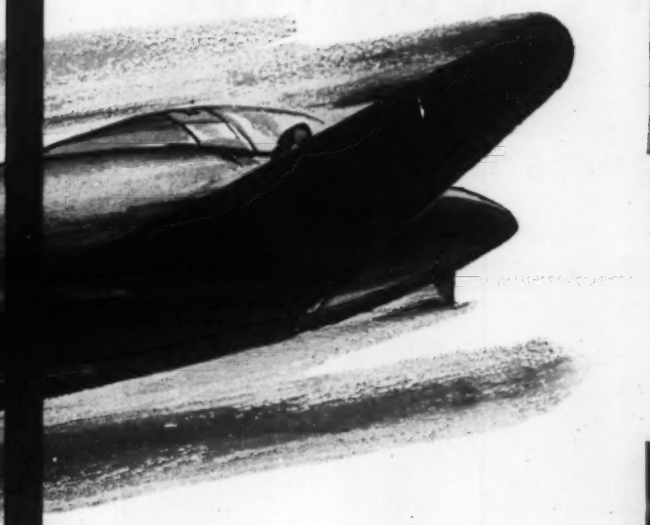


HEAT

2,000 degree jet blast!

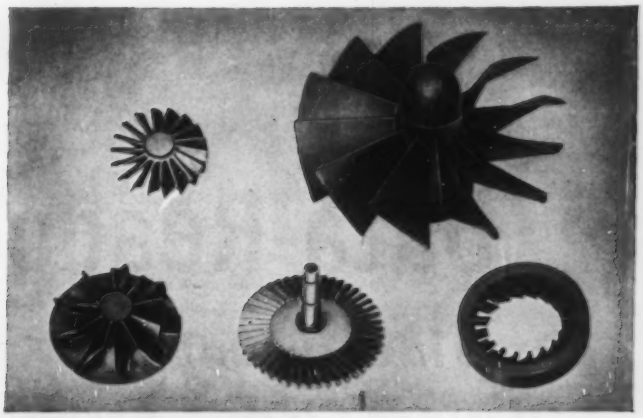
The jet engine tailpipe of the Navy's A4D "Skyhawk" operates at extremely high temperatures. That is just one of the many reasons why this part is made of MULTIMET alloy. This is one of 6 HAYNES wrought alloys that have unusual resistance to high temperatures and oxidation. Because of their exceptional properties, HAYNES alloys are being used extensively in such parts as after-burner components, jet engine tailpipes, turbine blades, and nozzle vanes.

tough problems



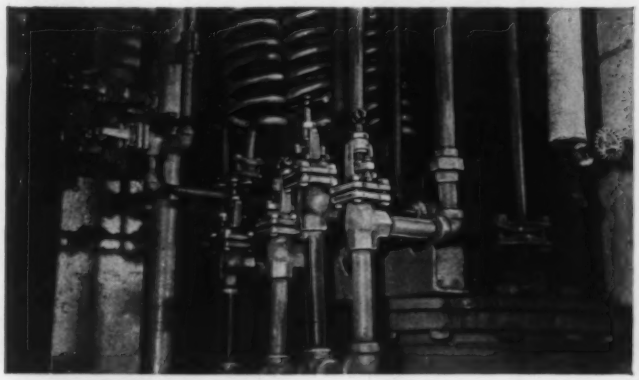
If you have an application that is creating a tough heat, wear, or corrosion-resistance problem, you will find it profitable to check with HAYNES Stellite Company. In practically every industry, you will find HAYNES Alloys doing a better job, lasting longer, reducing maintenance and proving most economical.

Tell us your problem and we will send you descriptive literature on the HAYNES Alloy best suited to solve it. Write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.



PRODUCTION Intricate turbine wheels mass-produced.

HAYNES' investment-casting method offers a selection of alloys developed for economical operation over a wide temperature range. Blades and wheels are produced as one integral part to as-cast tolerances that permit operation with unusually fine clearances at high speeds.



CORROSION Withstands corrosive chlorine 10 years!

Handling highly corrosive liquid chlorine was an expensive maintenance problem—until valves made of HASTELLOY alloy C were installed. This is just one of the many corrosive difficulties met by HAYNES Alloys. They also have excellent resistance to hot mineral acids, strongly oxidizing salts, and powerful gaseous oxidants over a wide range of temperatures and concentrations.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation

UNION CARBIDE

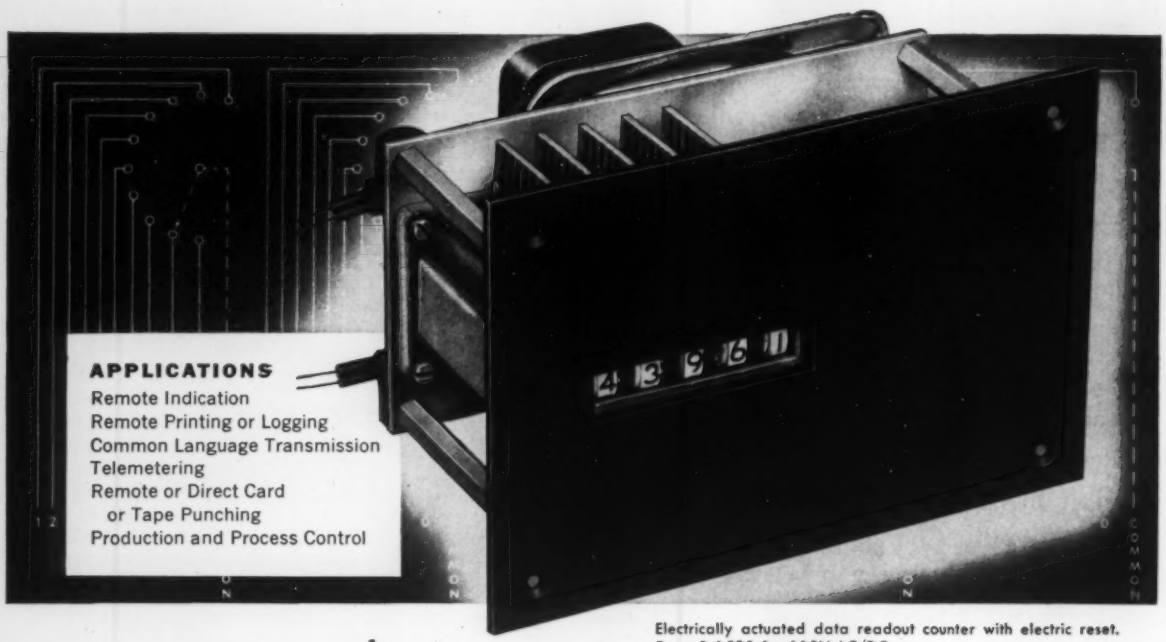
"Haynes," "Multimet," "Hastelloy" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 440 on page 19

NEW

Data-Readout Counter

Provides 100,000 Distinct Circuit Arrangements



Electrically actuated data readout counter with electric reset. Form B-1538 for 110V AC/DC.

FUNCTIONS

Analog to Digital Conversion
Serial or Parallel Circuit Transmission
Continuous or On Demand Electrical Readout
Continuous Visual Readout
Visual and Electrical Data Storage
Predetermining
Repeat Predetermining
Sequential Programming

Veeder-Root's new series of Data Readout Counters combines visual indication with electrical readout for remote indication, recording, and controlling applications. *Electrically* or *mechanically* driven and provided with *manual* or *electric* reset, these counters present a positive display of accumulated totals and automatically create specific control circuit contact closures for each number visually displayed. Each instrument, with its five figure capacity, provides 100,000 distinct circuit arrangements which lend themselves to the most exacting control and transmission requirements. The counters are compatible with standard data processing equipment and offer a wide variety of applications in the industrial control and data processing fields.

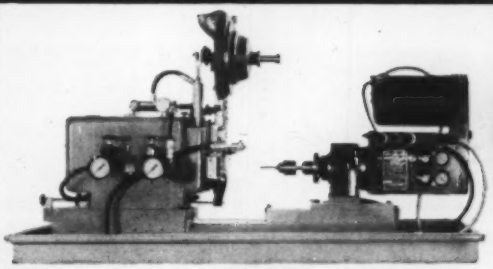
Veeder-Root Inc.

"THE NAME THAT COUNTS"

Hartford, Conn. • Greenville, S. C. • Chicago • New York • Los Angeles
San Francisco • Montreal • *Offices and Agents in Principal Cities*

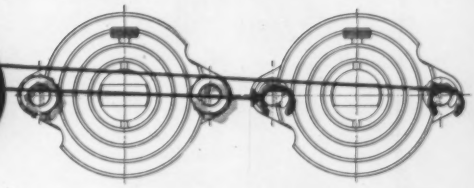
Circle 441 on page 19

Waldes Truarc Retaining Rings Eliminate Machining and Parts—Cut Assembly Time on Drill and Tapper



Beco Model 410 Drill and Tapper

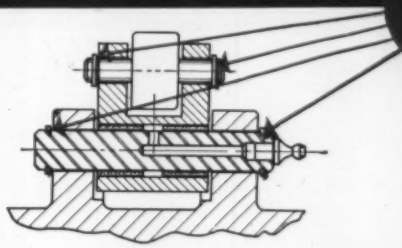
The Batchelder Engineering Co., Inc., Springfield, Vermont uses 4 different sizes of 2 different type Waldes Truarc rings in their new BECO Model 410 Automatic Drill and Tapper. Truarc rings speed assembly, reduce machining, improve design.



ALTERNATE DESIGN TRUARC DESIGN

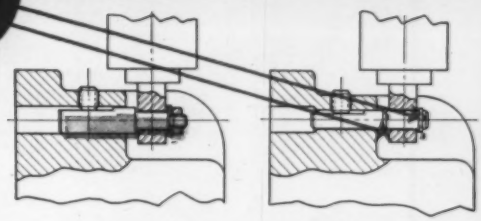
Clamp Cylinder Rod Stop Assembly

Truarc "E" Rings (Series 5133) replace stop nuts in the Clamp Cylinder assembly. They eliminate need for threading 2 rods ...the danger of cross-threading nuts...and costly rejects. Truarc Rings cut assembly time and cost.



Bell Crank Pivot Assembly

Truarc Rings (Series 5100) in Bell Crank Pivot assembly permit grease hole not possible with cotter pin fastener. Use of nuts would have increased machining and assembly costs considerably.



ALTERNATE DESIGN TRUARC DESIGN

Hopper Cylinder Anchor Pin Assembly

2 Truarc Rings (Series 5100) secure and position end of vertical air cylinder. Rings eliminate extra cost of machining 3-diameter pin, threading and undercutting...plus nut and washer. Assembly is quick and sure.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

WALDES
TRUARC®
RETAINING RINGS
WALDES KOHINOOR, INC.
47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

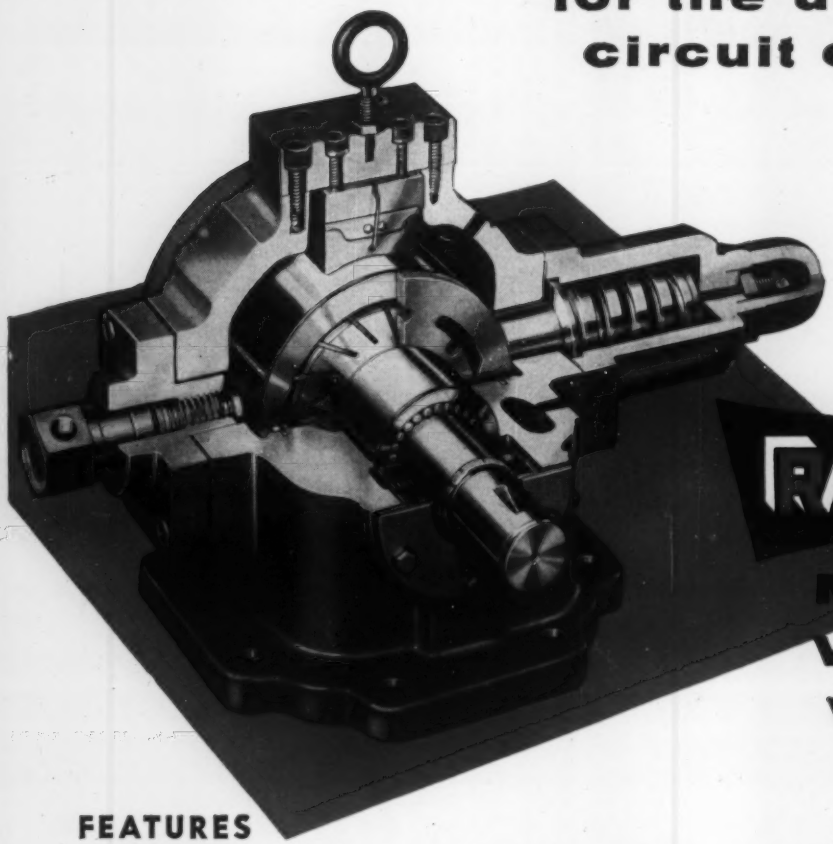
Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name .....
Title .....
Company .....
Business Address .....
City ..... *Zone* ..... *State* .....

MD-069

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

for the ultimate in circuit efficiency

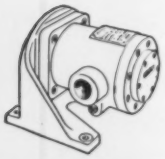


New RACINE® Model R Variable Volume PUMP

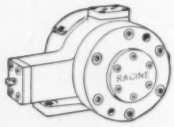
FEATURES

- **VARIABLE VOLUME DESIGN** simplifies the circuit. Relief valves with extra piping are eliminated.
- **AUTOMATIC BUILT-IN GOVERNOR** regulates volume of oil delivered to exact requirements of circuit. This feature reduces heat and saves horsepower.
- **VARIOUS BUILT-IN GOVERNORS** are available for electric, hydraulic or manual operation. Where needed, two pressure governors are provided.
- **THIS PUMP** is subplate mounted, result is simple installation and ready maintenance. Machine downtime is reduced.
- **DESIGNED FOR 40 GPM** maximum volume with built-in control to regulate flow to lower volume. Operating pressure 1000 PSI continuous duty, 1250 PSI intermittent duty.
- **SALES AND SERVICE OFFICES** in all industrial centers throughout the country. Write today for *new* fully descriptive bulletin.

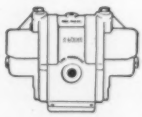
OTHER RACINE HYDRAULIC COMPONENTS "THEY WORK BETTER TOGETHER"



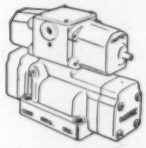
FLUID MOTORS



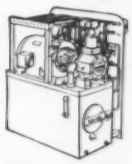
Model Q Variable Volume PUMPS



PRESSURE BOOSTERS



4-WAY VALVES



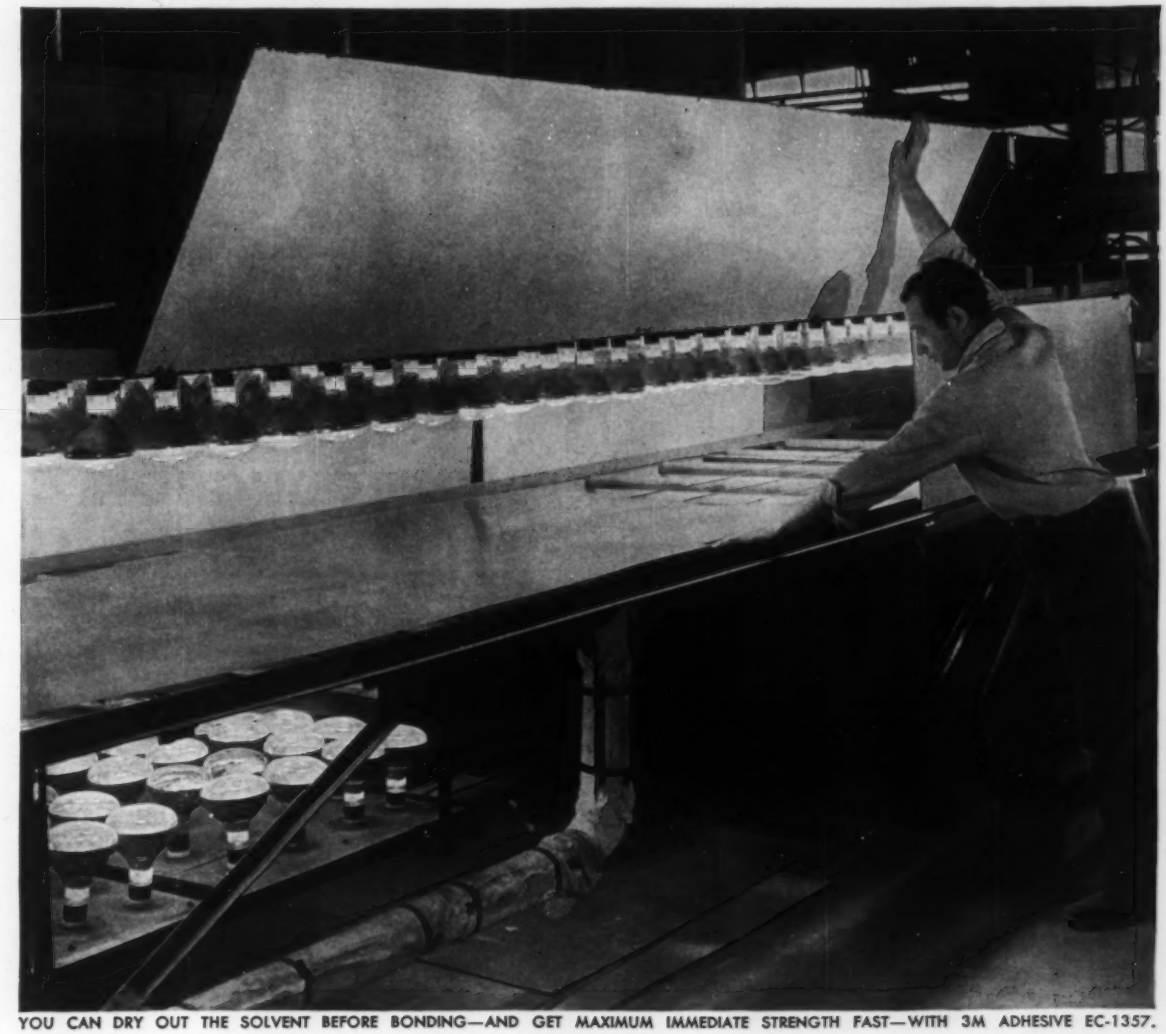
POWER UNITS

RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street
RACINE, WISCONSIN

NFPA National Fluid Power Association Member

Circle 443 on page 19

Speed high-strength sandwich bonding by predrying 3M adhesive EC-1357



YOU CAN DRY OUT THE SOLVENT BEFORE BONDING—AND GET MAXIMUM IMMEDIATE STRENGTH FAST—WITH 3M ADHESIVE EC-1357.

Here's new speed in making light, rugged sandwich panels for non-load-bearing uses!

It's EC-1357. This specially formulated, fast adhesive from the laboratories of 3M gives you high bond strength *immediately!* With infrared ovens, you can dry the solvent out of EC-1357 before bonding. Heat absorption is fast, due to EC-1357's dark color. You eliminate unnecessary drying and storage time.

You need no clamps or heated presses, just cold press or nip roller. What's more, this cold bond continues to cure at room temperatures—gains added strength with age.

On metal or paper honeycomb cores, EC-1357 builds up a fillet for bigger bonding area and strength. Use EC-1357 with glass foam cores, too.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! Consult 3M Research, contact your 3M Field Engineer or write on your company letterhead for information and free literature to: 3M, Dept. 106, 417 Piquette Ave., Detroit 2, Mich.

PRODUCT OF 3M COMPANY RESEARCH

MINNESOTA MINING AND MANUFACTURING COMPANY • ADHESIVES AND COATINGS DIVISION

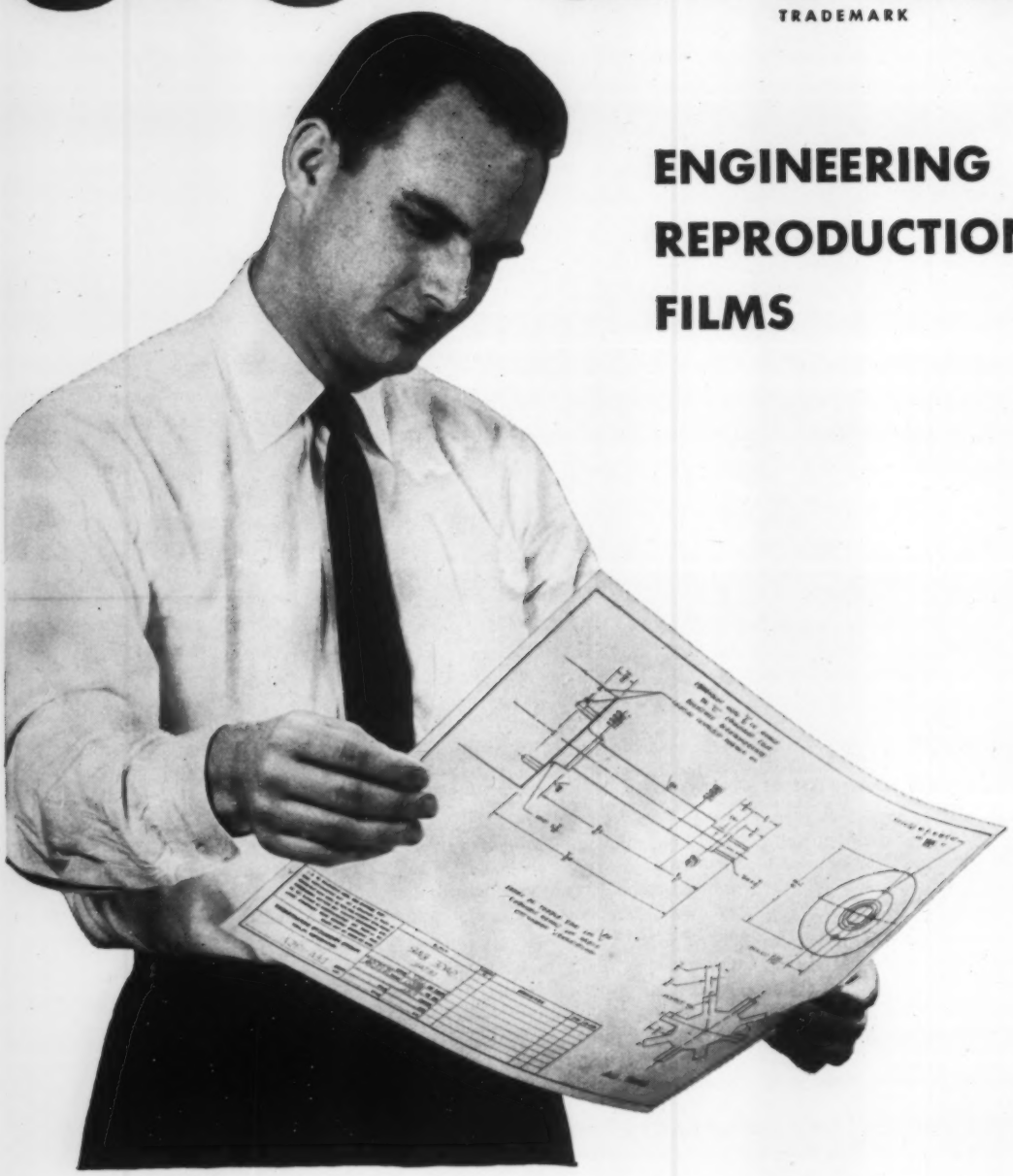
417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N.Y. 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.

Circle 444 on page 19

Du Pont Announces

Cronaflex

TRADEMARK



ENGINEERING
REPRODUCTION
FILMS

WHAT IS Cronaflex?

CRONAFLEX is a new line of photographic reproduction materials on Du Pont Cronar® polyester film base. CRONAFLEX films are available in three types:

1. **DIRECT POSITIVE FILM** for making sharp black-line positives directly from pencil or ink drawings.
2. **CONTACT FILM** for negative "same-size" reproduction of originals for use in producing accurate positive intermediates.
3. **PROJECTION FILM** for use in cameras or enlargers to produce negative or positive copies.

WHY Cronaflex?

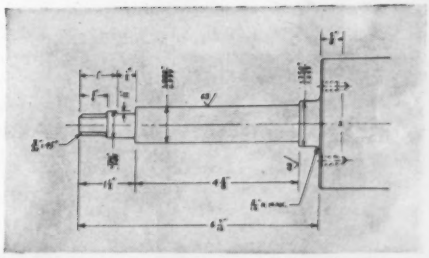
Because of their unique properties, CRONAFLEX Engineering Reproduction Films offer decisive advantages:

- **CRONAFLEX**, thanks to its "Cronar" base, is unbelievably rugged, absorbs a minimum amount of moisture, and is the most dimensionally stable, tear-resistant engineering film you can use.
- **CRONAFLEX** will not tear, kink, shatter, or become brittle. It will withstand repeated wear and abuse under any shop or storage conditions.
- **CRONAFLEX** has a matte surface that provides the finest pencil and ink acceptance yet devised. Lines do not smudge, can be drawn—or erased and redrawn—on either side of the film.
- **CRONAFLEX** dries rapidly. Intermediates can be ready for reproduction in fifteen minutes or less.

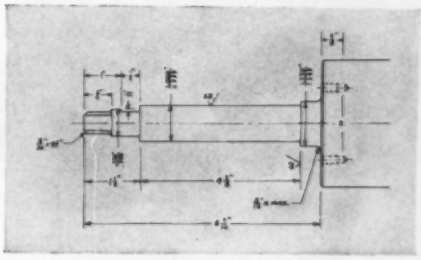
WHO CAN USE Cronaflex?

Engineers, draftsmen, blueprinters, cartographers, architects, surveyors. CRONAFLEX films on .004" "Cronar" base will fill your needs for long-lasting intermediates and duplicate originals. For use where dimensional stability is very critical, CRONAFLEX Direct Positive and Projection Films are available on .007" base.

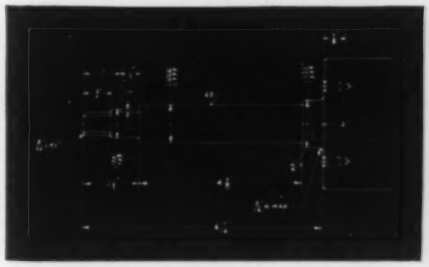
FOR MORE INFORMATION on these revolutionary new films, fill in the coupon. E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, Toronto.



CRONAFLEX Direct Positive Film gives you a positive, black-line reproduction from original pencil or ink drawings. It can be exposed in direct process machines or conventional contact printing equipment. Can be handled and processed in subdued room light.



CRONAFLEX Contact Film gives you the positive intermediate for diazo or blue printing where negative-positive steps are utilized. CRONAFLEX will not break, crack or discolor.



CRONAFLEX Projection Film can be exposed in a camera, enlarger, or contact frame; it gives you a negative copy from an original drawing *or* a positive copy from a negative intermediate.

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

DU PONT CRONAFLEX
for Functional Photography

Photography with a purpose . . . not an end in itself but a means to an end.

E. I. du Pont de Nemours & Co. (Inc.) MD-6
Photo Products Department
2420-17 Nemours Building
Wilmington 98, Delaware

Please send me literature on CRONAFLEX.

Name _____

Firm _____

Street _____

City _____ State _____

Largest bronze centrifugal casting ever made, 54¼" O.D. x 49½" I.D. x 346½" long. Charge weight—72,300 pounds.

At Sandusky,

GIANTS ARE ROUTINE...

Small wonder. We serve giant industries . . . paper-making, shipbuilding, metalworking, atomic energy, petro-chemical, and others . . . with centrifugally cast cylinders and tubular parts, many of which can't be made by any other process to the exacting standards required.

It's the 47 years of specialized experience coupled with unequalled manufacturing facilities . . . that makes it routine for our engineers and production teams to cast and machine *cylinders from 7" to 54" O.D. and up to 33 feet in length* . . . in a wide range of alloys meeting special performance requirements.

Do you need a giant cylindrical form . . . or a small one . . . machined to exact working dimensions? Send us your specifications; we'll reply promptly.

Sandusky Centrifugal Castings offer you 4 important advantages:

1. ***SUPERIOR MECHANICAL PROPERTIES*** —to meet exacting design requirements
2. ***UNIFORM SOUNDNESS***—free from harmful inclusions and porosity
3. ***HIGHEST QUALITY***—to insure long, dependable, trouble-free service
4. ***JOB-READY CASTINGS***—machined to your exact specifications, eliminate extra costs from rejects, down-time, loss of production

CENTRIFUGAL CASTINGS

Sandusky Foundry & Machine Company

SANDUSKY, OHIO • *Stainless, Carbon, Low Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys*

Circle 446 on page 19

build reliability into your product with OHMITE® COMPONENTS

close-control RHEOSTATS

All-ceramic and metal, close-control rheostats for unsurpassed dependability and smoothness of operation. Ten stock sizes, 25 to 1,000 watts.

wire-wound RESISTORS

A wide range of dependable, fixed, adjustable, tapped, and noninductive power wire-wound resistors. Also a wide range of precision resistors.

general-purpose RELAYS

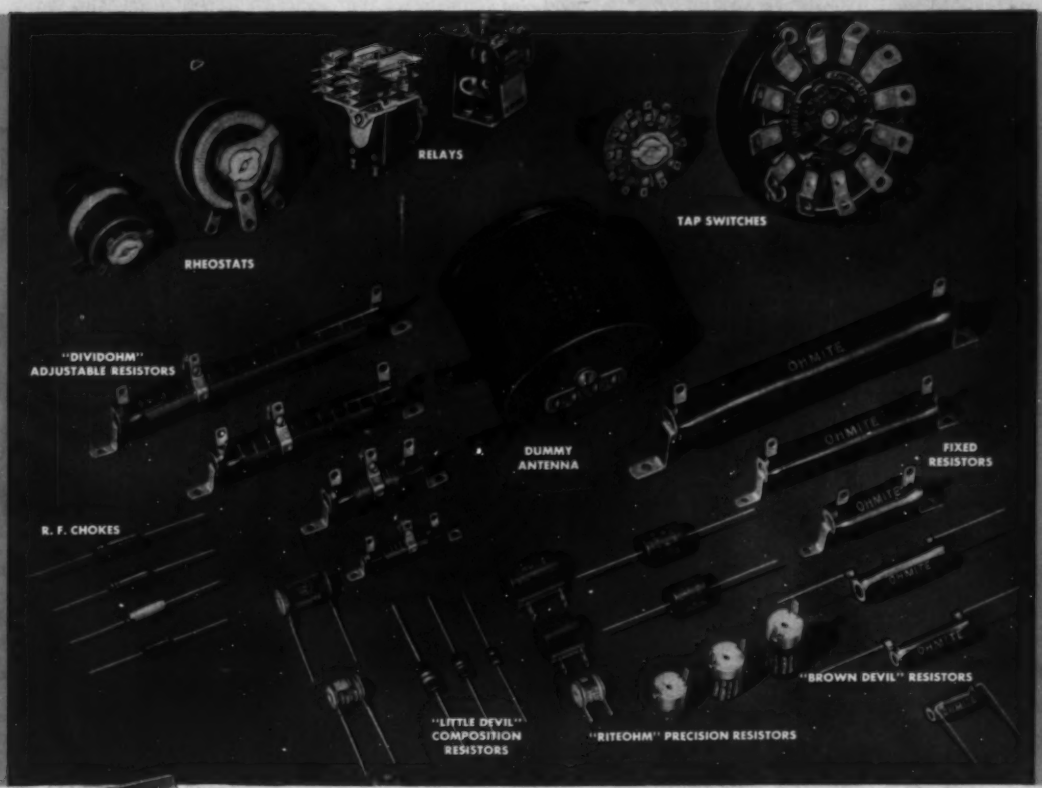
65 Types in four stock models. Good delivery on made-to-order relays. Contact current ratings up to 25 amps, AC or DC. Wide variety of contact arrangements. Hermetically sealed or dust-protective enclosures available.

high-current TAP SWITCHES

Five compact models, up to 100 amperes, AC, up to 12 taps. All-ceramic and metal construction. Silver-to-silver contacts, with self-cleaning rotor contact.

radio-frequency CHOKES

Single layer R.F. plate chokes and power line chokes on steatite or plastic cores. Protected by a special moisture-resistant coating.



WRITE on Company Letterhead for Catalog and Engineering Manual.

Be Right with OHMITE®

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS

Circle 447 on page 19

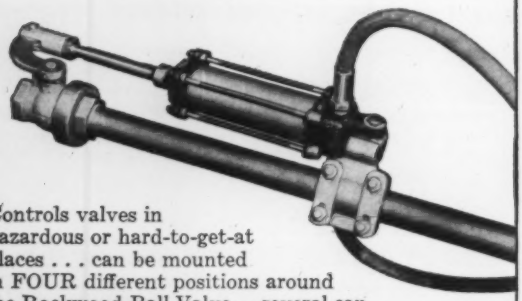
OHMITE MANUFACTURING COMPANY • 3618 Howard Street, Skokie, Illinois

Rockwood Ball Valves

- *Full round pipe size flow*
- *Leakproof service*
- *¼ turn opening and closing*
- *No maintenance*

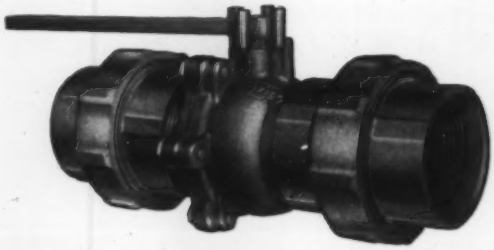
Air-Operated Ball Valves

For remote control use



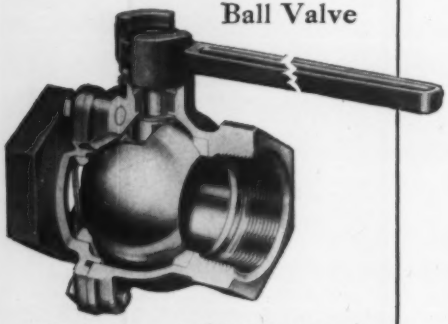
Controls valves in hazardous or hard-to-get-at places . . . can be mounted in FOUR different positions around the Rockwood Ball Valve...several can be controlled from one control board...available in a complete package unit from your distributor.

Male Thread Bronze Ball Valve



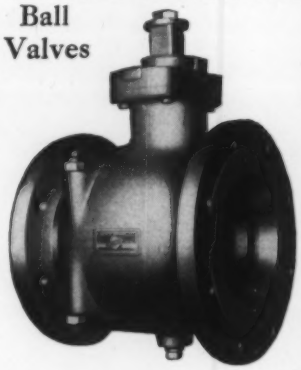
Full flow . . . with thread end, flanged end, union end or combination of same available with this valve. Longer life . . . greater strength. Size 2½" only.

Steam Ball Valve

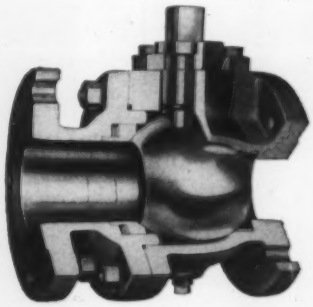


New Rockwood Ball Valve for use with steam handles up to 125 pounds of steam per square inch and 350 degrees F, with ease . . . opens and closes quickly. Pipe sizes ⅜" to 2".

6" and 8" Cast Steel Ball Valves



3" and 4" Cast Steel Ball Valves



Combines best features of plug cocks, gate and globe valves . . . made of medium carbon cast steel that meets specifications for carbon steel pressure castings as embodied in ASTM. Also made in other materials.

ROCKWOOD BALL VALVES

Write for complete data to Rockwood Sprinkler Company, 2161 Harlow St., Worcester 5, Mass. Distributors in all principal industrial areas.

ROCKWOOD

Tested and listed by Underwriters' Laboratories, Inc.

Circle 448 on page 19

"You can form dies 4 times faster with Formica S-52 die stock"

S-52 aircraft die used by Twin Coach Corp. for forming this beaded skin airplane wing part. It is machined to a tolerance of .005" and can easily be lifted by one man.

"We cut our die forming time from 4 months to 4 weeks when we switched from steel to Formica S-52 die stock," declares Stephen Chojnacki, general foreman, Aircraft Division plant, Twin Coach Corp., Buffalo.

"Twin Coach has been using Formica S-52 laminated plastics for over four years now, for pressing aircraft and coach parts. It's the most economical material we've ever used for this purpose.

"S-52 is easier to machine to close tolerances. It has a hard, dense structure that holds its shape. And its smooth surface never puts a pattern in the metal being formed."

Manufacturers interested in better, faster and cheaper forming of non-ferrous metal, plastic, wood, rubber, vulcanized fibre and other ductile materials — should check Formica S-52. Send today for your free copy of bulletin 604. Formica Corporation, subsidiary of American Cyanamid, 4514-7 Spring Grove Ave., Cincinnati 32, Ohio.

S-52 8 ways better than steel dies:

1. Faster, cheaper and easier to machine.
2. Easier to handle and move — it's light in weight.
3. Longer die life — some dies in use at Twin Coach for 4 years, withstand pressure up to 10,000 psi.
4. Rejects reduced from 50% with steel dies, to nothing with S-52 which prevents metal in dies from flaking off.
5. Takes deeper tooling — although easily machined, S-52 retains rigidity.
6. Prevents sticking, retains lubricant.
7. Eliminates tool drawings — die makers work directly from templates.
8. Offers more surface per pound per dollar

Save your engineers . . . . use Formica 4 the complete laminated plastics service

FORMICA

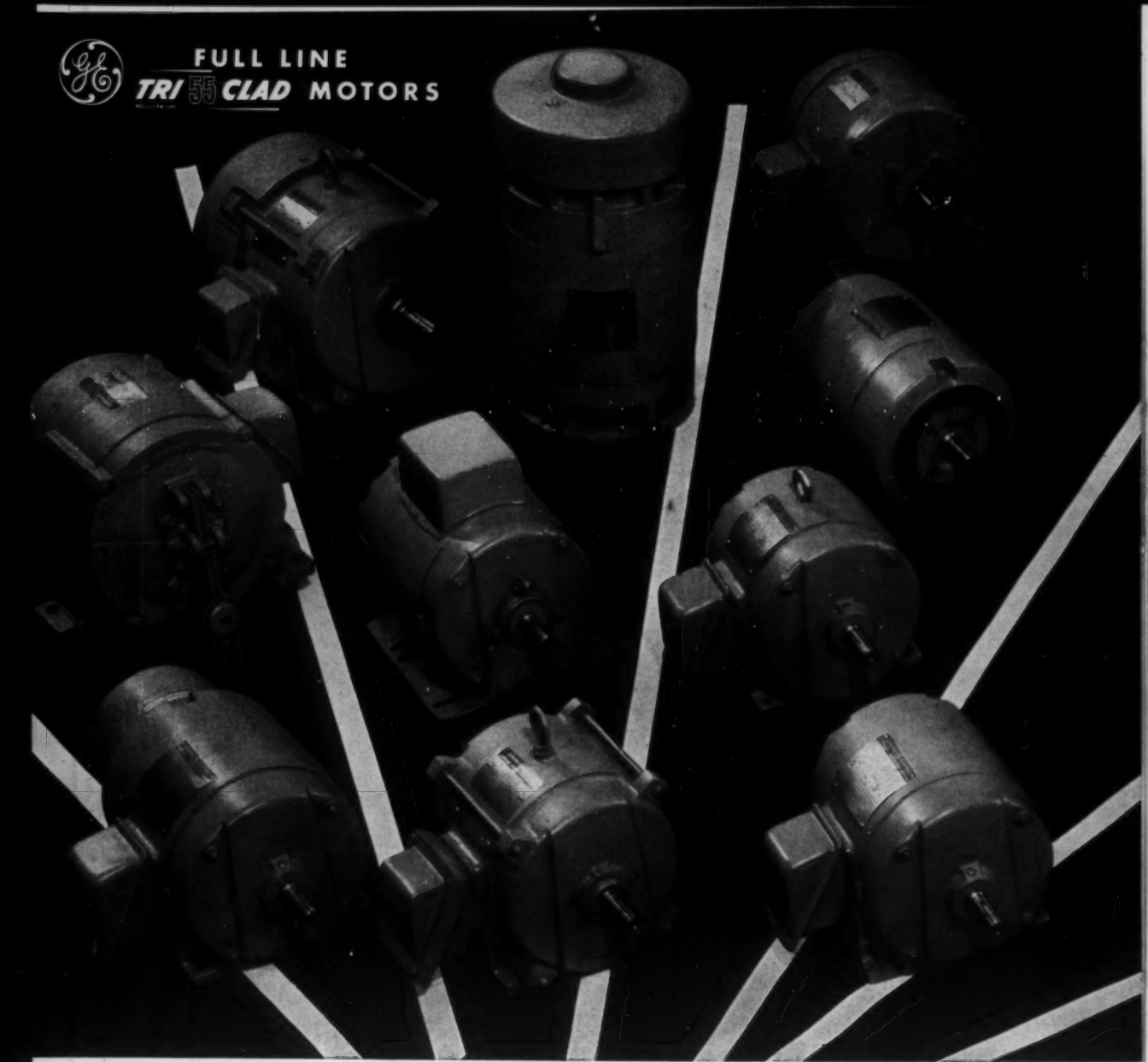
Subsidiary of CYANAMID

1. Application engineering **2. Research** **3. Fabricating** **4. Customer stock service**

FI-1422

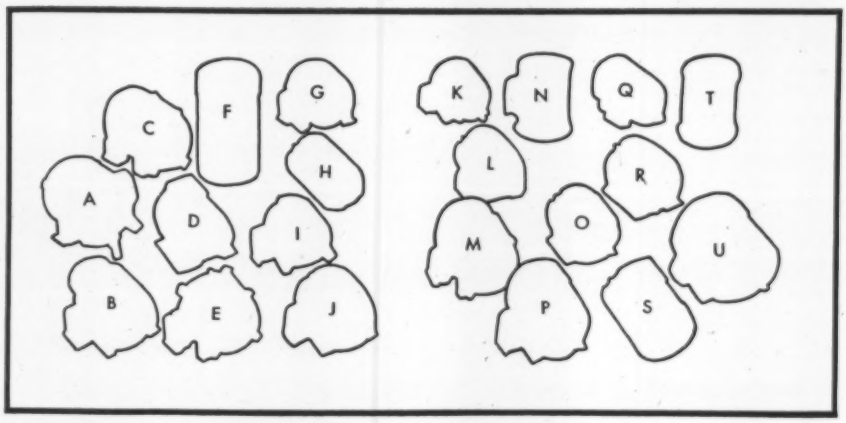
Circle 449 on page 19

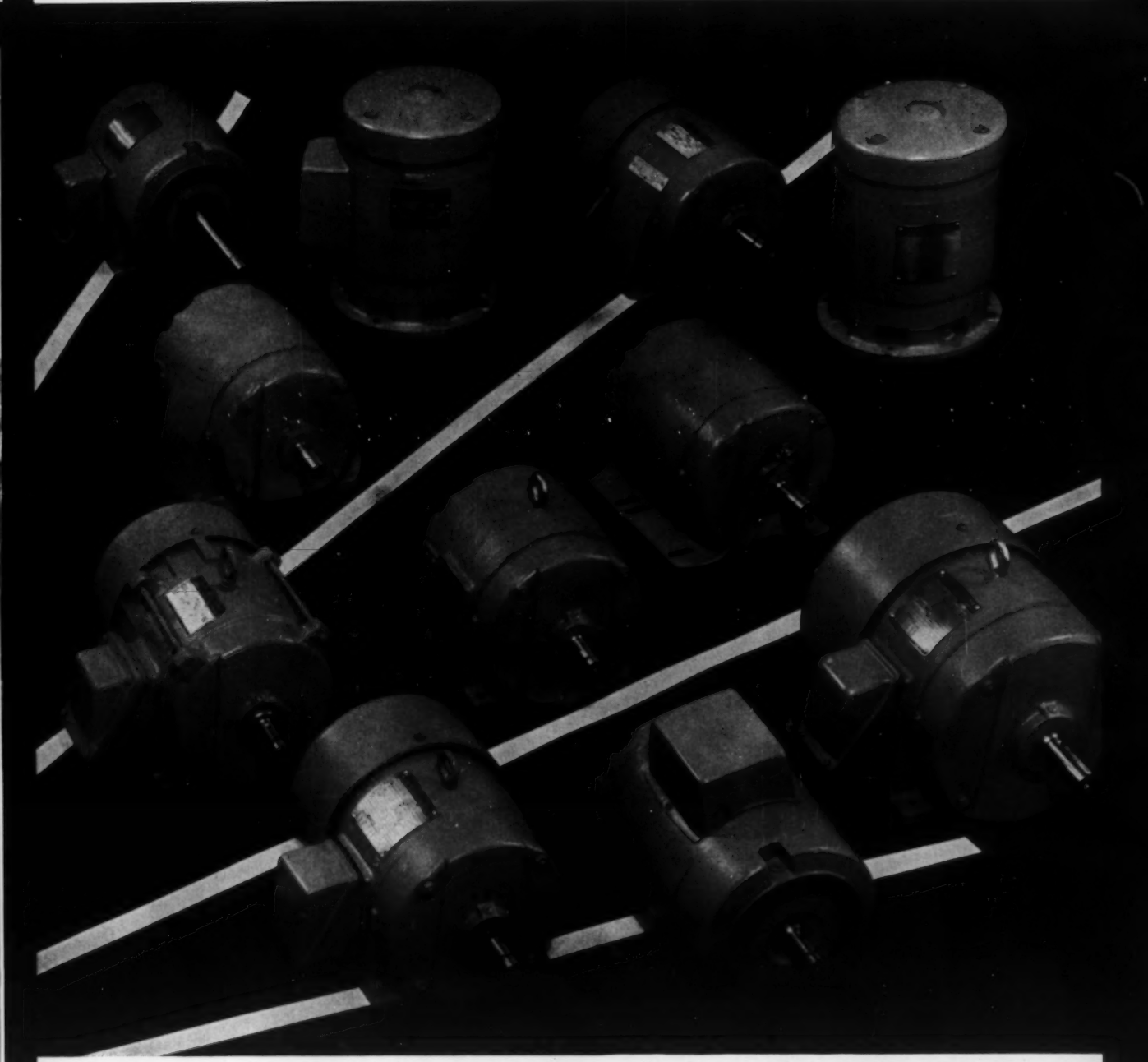
FULL LINE
TRI 55 CLAD MOTORS



THE MOTOR YOU NEED

A. Clutch-brake, dripproof, 2-3ϕ
B. Brake-motor, 2-3ϕ
C. Explosion-proof, fan-cooled, 2-3ϕ
D. Dripproof, resilient-base, 1ϕ
E. Explosion-proof, non-vent., 2-3ϕ
F. Vert. hollow-shaft, P-base, 2-3ϕ
G. Loom motor, 2-3ϕ
H. Dripproof, round frame, C-face, 2-3ϕ
I. TENV, standard-duty, 2-3ϕ
J. Standard dripproof, 2-3ϕ
K. Close-coupled pump, C-face, 2-3ϕ
L. Standard dripproof, 1ϕ
M. Explosion-proof, fan-cooled, 1ϕ
N. Vert. solid-shaft, P-base, 1ϕ
O. Enclosed, air-over, 2-3ϕ
P. TEFC, severe duty, 2-3ϕ
Q. Standard TEFC, 1ϕ
R. Dripproof, resilient-base, 2-3ϕ
S. Dripproof, round-frame, C-face, 1ϕ
T. Vert. solid-shaft, P-base, 1ϕ
U. TEFC, standard duty, 2-3ϕ





IS IN THIS PICTURE

Now! You never have to take *less* than General Electric Tri-Clad 55 motor quality—because G.E. now offers you a *complete line* of Tri-Clad 55 motors to assure you of a perfect match of motor to machine.

In most cases, you'll choose the rugged, versatile Tri-Clad 55 standard motors (single- or polyphase, dripproof or enclosed). For those special industry applications, General Electric also offers you a full line of industry-specified motors (for example, end-mounted, built-in motors for the pump and machine tool industries).

Of course, all Tri-Clad 55 motors incorporate these extra-value features: Mylar* polyester film insulation for longer motor life, minimum maintenance; silicone coating on the motor stator assembly for maximum protection against failure due to moisture; Formex† magnet wire insulation for protection against heat-aging and abrasive dusts; non-wicking leads; more rigid construction; easier installation and servicing; and many, many more.

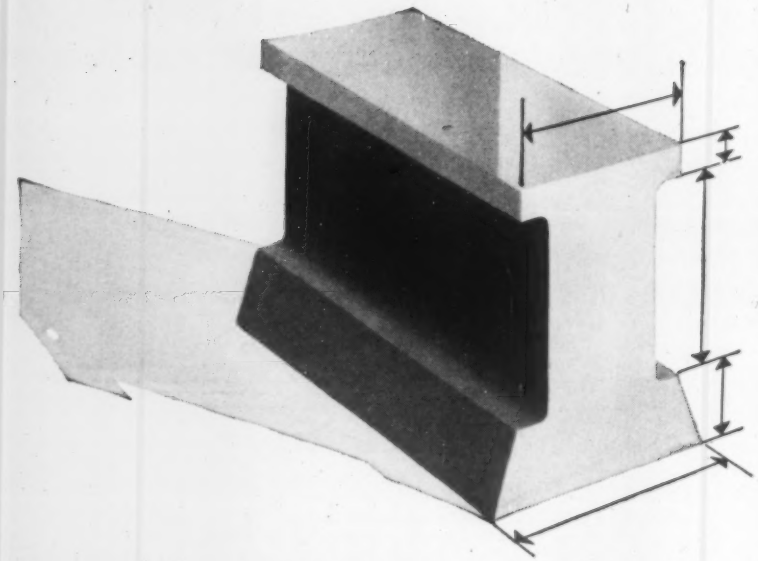
For expert engineering assistance in selecting the right G-E motor for your application, contact your nearby G-E Apparatus Sales Office. Or, for more information about General Electric's full line of Tri-Clad 55 motors, write: General Electric Co., Section 840-6, Schenectady 5, N. Y. and ask for bulletins GEA-6240 and GEA-5980.

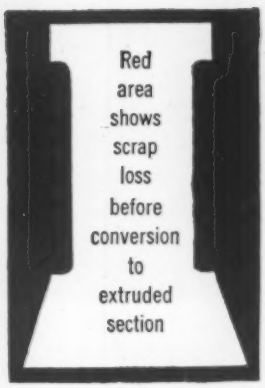
†Reg. trademark of General Electric Co. *Reg. trademark of DuPont Co.

GENERAL ELECTRIC

Circle 450 on page 19

Cost per clamp cut from $1.06 to 58¢ with J&L hot extruded cold drawn section





This manufacturer cut the cost of contact clamps 45% by converting to J&L extruded sections. Previous cost of $1.06 per part involved costly milling and scrap loss from cold drawn 1½" x 1" flats.

Here's how extruded sections can cut your cost:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero.
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

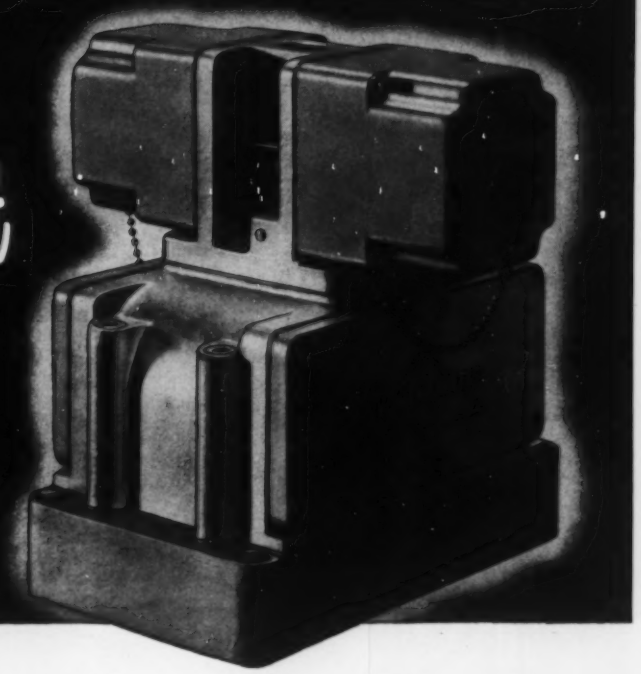
Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. Available in a wide range of carbon and alloy steels. For specialty alloy and tool steels, submit inquiry. Get complete details by writing to the Jones & Laughlin Steel Corporation, Dept. 410, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

Jones & Laughlin STEEL ... a great name in steel

Circle 451 on page 19

100% J.I.C.

at no EXTRA cost



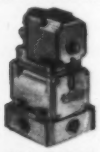
Another *Plus Value*

— found in *NOPAK-MATIC* poppet-type air control valves

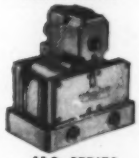
- All models subplate mounted
- Solenoid inoperative when covers are removed
- Dust- and splash-proof solenoid covers
- Manual over-ride button
- Covers chained to valves
- Full I.P.S. capacity
- Dryseal pipe threads
- Corrosion-resistant materials
- Split-second response

300 SERIES
2-, 3-Way
Master Valves

400 SERIES
4-Way
Master Valves



310 SERIES
2-, 3-Way
Single Solenoid
Pilot Operated



410 SERIES
4-Way
Single Solenoid
Pilot Operated

320 SERIES
2-, 3-Way
Double Solenoid
Pilot Operated

420 SERIES
4-Way
Double Solenoid
Pilot Operated

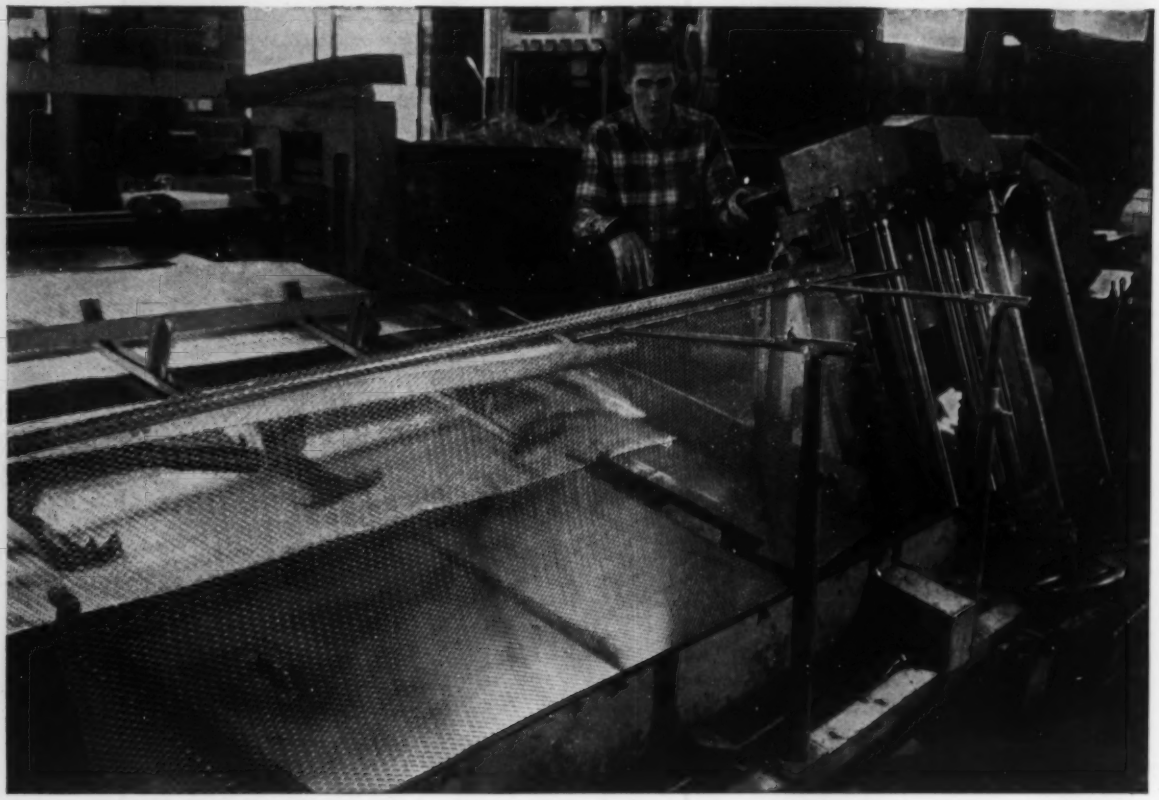
CATALOG 105 describes all the NOPAK-MATIC Plus Values in detail, gives complete installation and parts data. Send for your catalog now and it will be forwarded promptly. NOPAK-MATIC *Plus Value* Valves are available in ¼", ⅜", ½" and ¾" pipe sizes for 2-, 3-Way Normally Open or Normally Closed or 4-Way operation with master (air), single or double solenoid pilot control heads.

NOPAK *VALVES and CYLINDERS*

GALLAND-HENNING NOPAK DIVISION • 2752 South 31st St. • Milwaukee 46, Wis.

Circle 452 on page 19

MATERIAL SELECTION



Pulling a Bethcon sheet apart without damage to the galvanizing

Take a 9-in. strip of galvanized steel, cut slits in it about 1/16-in apart, then expand it into a lattice-like sheet 27 in. wide—and you have metal lath. Who would suppose that galvanized steel could take such punishment?

Yet that's just what is happening here to a 25-ga sheet of Bethcon galvanized steel. It's probably the most torturous test that a galvanized sheet has ever been subjected to. Naturally, the steel must be strong yet ductile, neither too hard nor too soft. The coating of zinc must be tight enough not to come off under the twisting action which takes place in the expanding operation.

You couldn't do this with just any old galvanized sheet, yet Bethcon comes through the ordeal with a smile. That's because Bethcon is galvanized by Bethlehem's continuous process, which bonds zinc to steel so tightly that the coating won't crack even when the sheet is doubled back on itself. This process also includes continuous annealing, which gives the basic steel a fine equiaxed grain for just the ductility needed.

Continuous galvanizing also makes Bethcon available in coils as well as cut lengths, which opens up the doors to long-run production economies. It also means that Bethcon can be used in making long-length products not feasible with conventional hot-dipped sheets.

In other words, in Bethcon designers have a remarkably good material to work with. Its low cost, easy formability, strength—these and other advantages are firing the imagination of design and production men throughout the metal manufacturing industry.

Perhaps the combination of steel's strength and zinc's resistance to corrosion, as embodied in Bethcon sheets, might prove the answer to a problem of yours. Our nearest sales office will be glad to lend a hand on the project.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Circle 453 on page 19

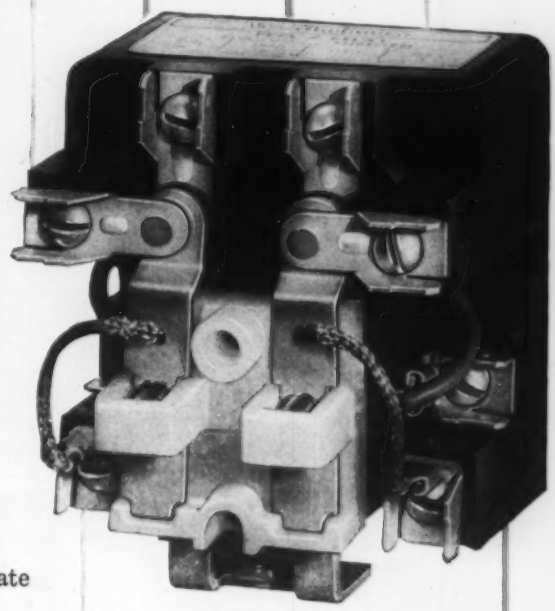
Does A Big Job

Takes Less Space

TYPE Z RELAY

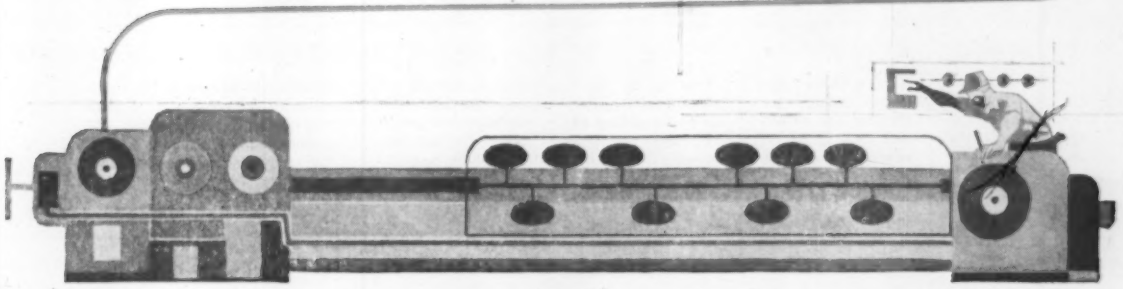
by Westinghouse

Small, versatile, amazingly rugged, this new Westinghouse relay is designed for long life and high reliability. The relay user who has space problems . . . wants a lot of relay in minimum mounting space finds Type Z ideally suited. Type Z meets U. L. Standards for 230 volts, is equipped with double-pole double-throw contacts of fine silver. Coil and core are interchangeable for a-c or d-c operation. An ideal relay for auxiliary multiple-circuit switching of light loads, small motors or for operating larger contactors or starters. J-80262



YOU CAN BE SURE...IF IT'S Westinghouse

Nylon armature insulating plate
Encapsulated removable coils
Firm contact pressure, low resistance



Circle 454 on page 19

How to Select and Apply

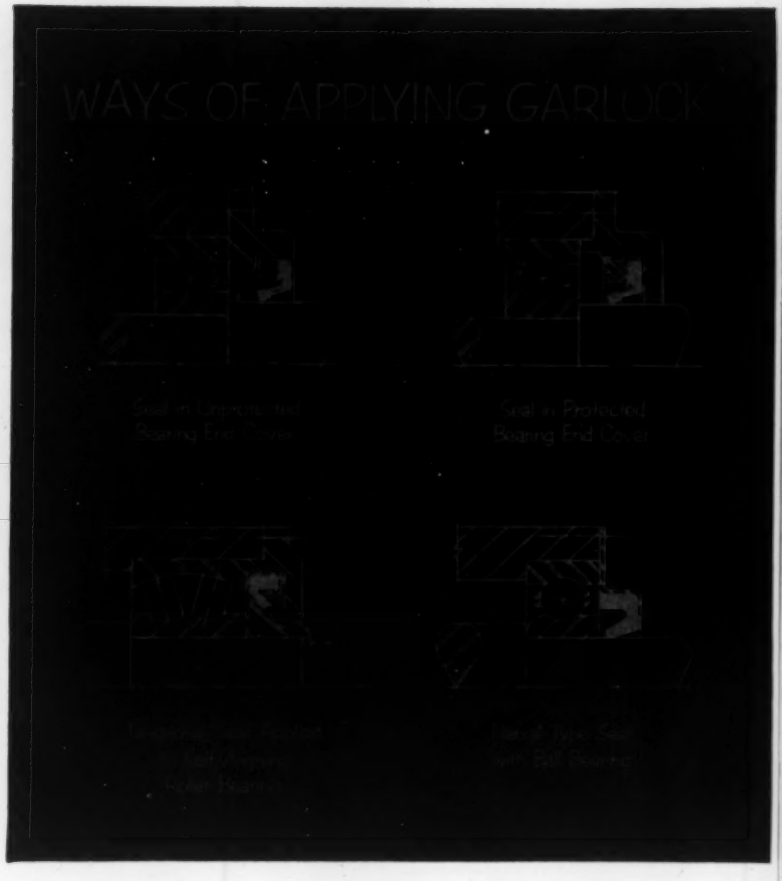
Selecting a Seal

Any ball or roller bearing seal must do two things: (1) It must keep lubricants in; and (2) It must keep dirt and grit out.

Factors to consider when selecting a seal are whether the shaft operates at high or low speed, whether the bearing load is heavy or light and whether the operating temperatures are high or normal. Also remember that the sealing of oil requires a more efficient seal than the retention of grease.

Seal Types

There are, of course, many kinds of seals used to protect bearings to some degree. Unit or lip type seals, such as the Garlock Klozure* Oil Seals illustrated, provide the best protection for automobiles, tractors and industrial machinery.



A

shows a Garlock Springless Klozure Oil Seal used where heavy lubricants are to be contained and dirt excluded.

B

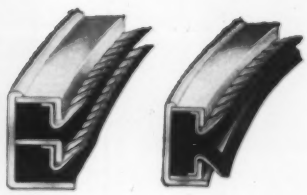
shows a Klozure with finger spring, very efficient for normal and high speed oil sealing on all size shafts.

C

shows a lip type Klozure with garter spring for sealing oil at normal and high speeds on shafts from 1" to 10".

D

shows a Klozure oil seal with combination finger and garter spring for use on large shafts operating under severe conditions.

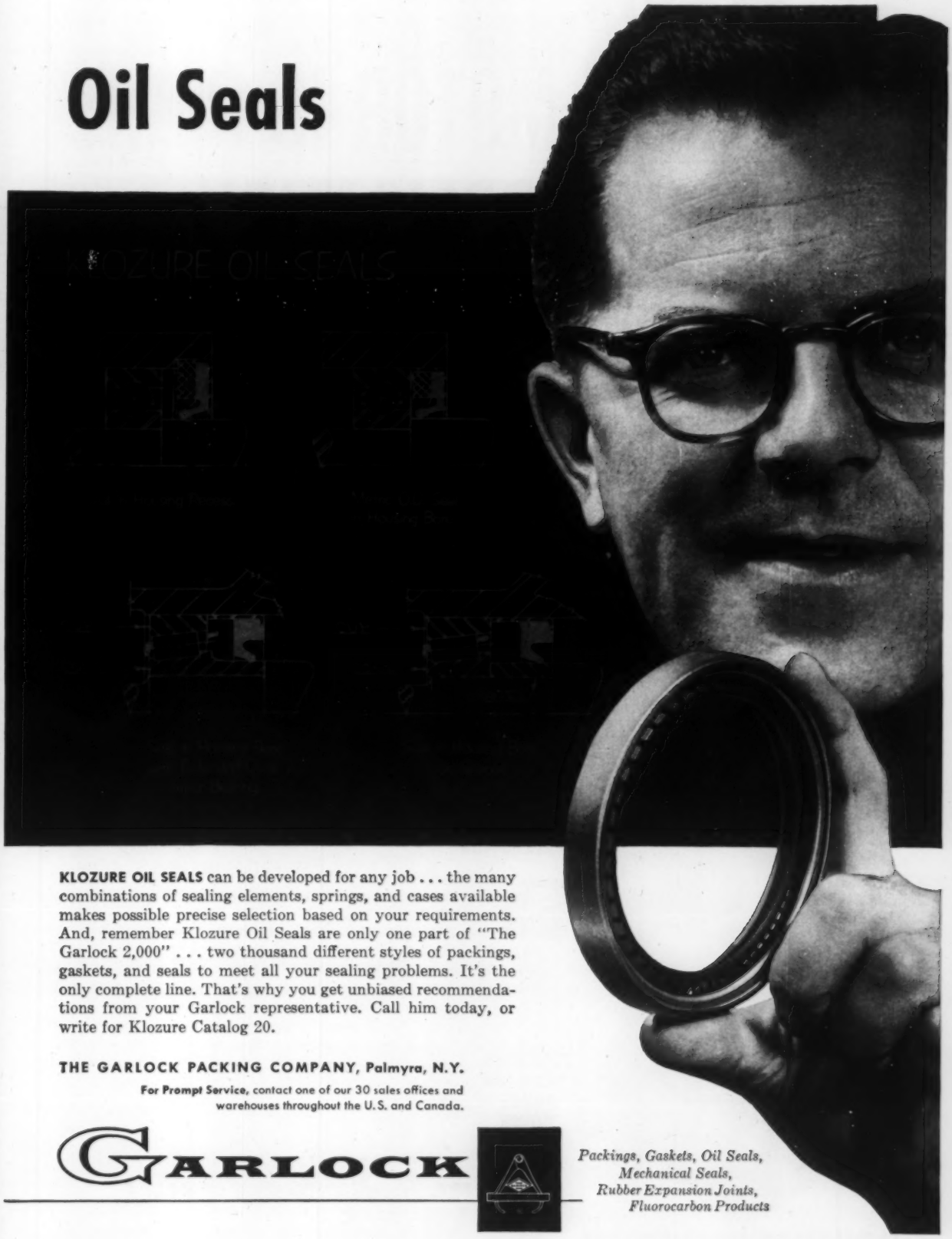


E **F**

Klozure Oil Seals are also available in dual tandem (E) or dual opposed (F) constructions for unusual sealing problems caused by operational or environmental conditions.

*Registered Trademark

Oil Seals



KLOZURE OIL SEALS can be developed for any job . . . the many combinations of sealing elements, springs, and cases available makes possible precise selection based on your requirements. And, remember Klozure Oil Seals are only one part of "The Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet all your sealing problems. It's the only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him today, or write for Klozure Catalog 20.

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

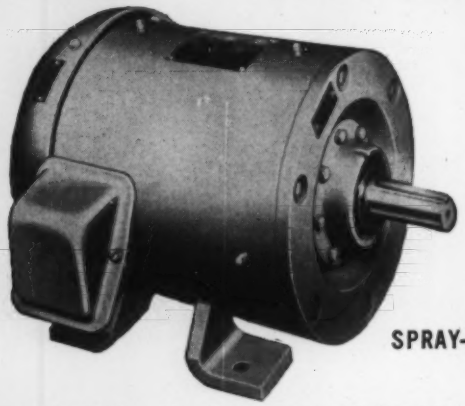
For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

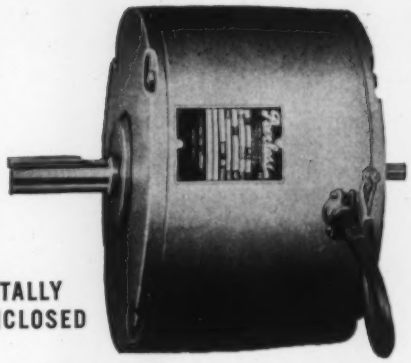
Circle 455 on page 19

ONLY ONE MOTOR IS RIGHT FOR YOUR APPLICATION...



SPRAY-TIGHT

Fan cooled; 7½ HP; Navy; Hi-shock to Navy Spec. MIL-M-17060A.

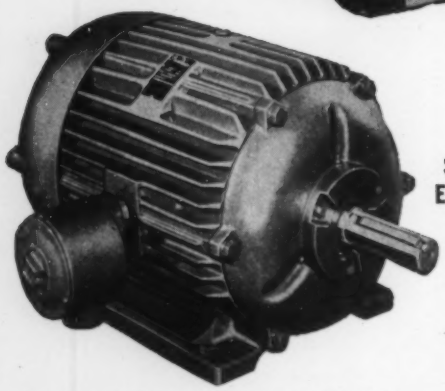


TOTALLY ENCLOSED

Blower and Drive Motor; 4 HP; air drawn over motor.

SPECIAL CONSTRUCTION

Motor to fit customer's application design.



STANDARD EXPLOSION-PROOF MOTOR

1 to 30 HP; also with NEMA C face and NEMA D flange.

● One thing's certain—just one motor is right for your application. Design engineers turn to Peerless more often than ever today because Peerless is equipped to produce the motors that power their machines best. There's no need to fit the machine to the motor. Peerless has hundreds of motor designs—many of them created specifically to meet OEM problems. Give your next motor problem to the Peerless Representative near you or write directly to the factory. We'll work with you to develop the one motor that meets your needs best.

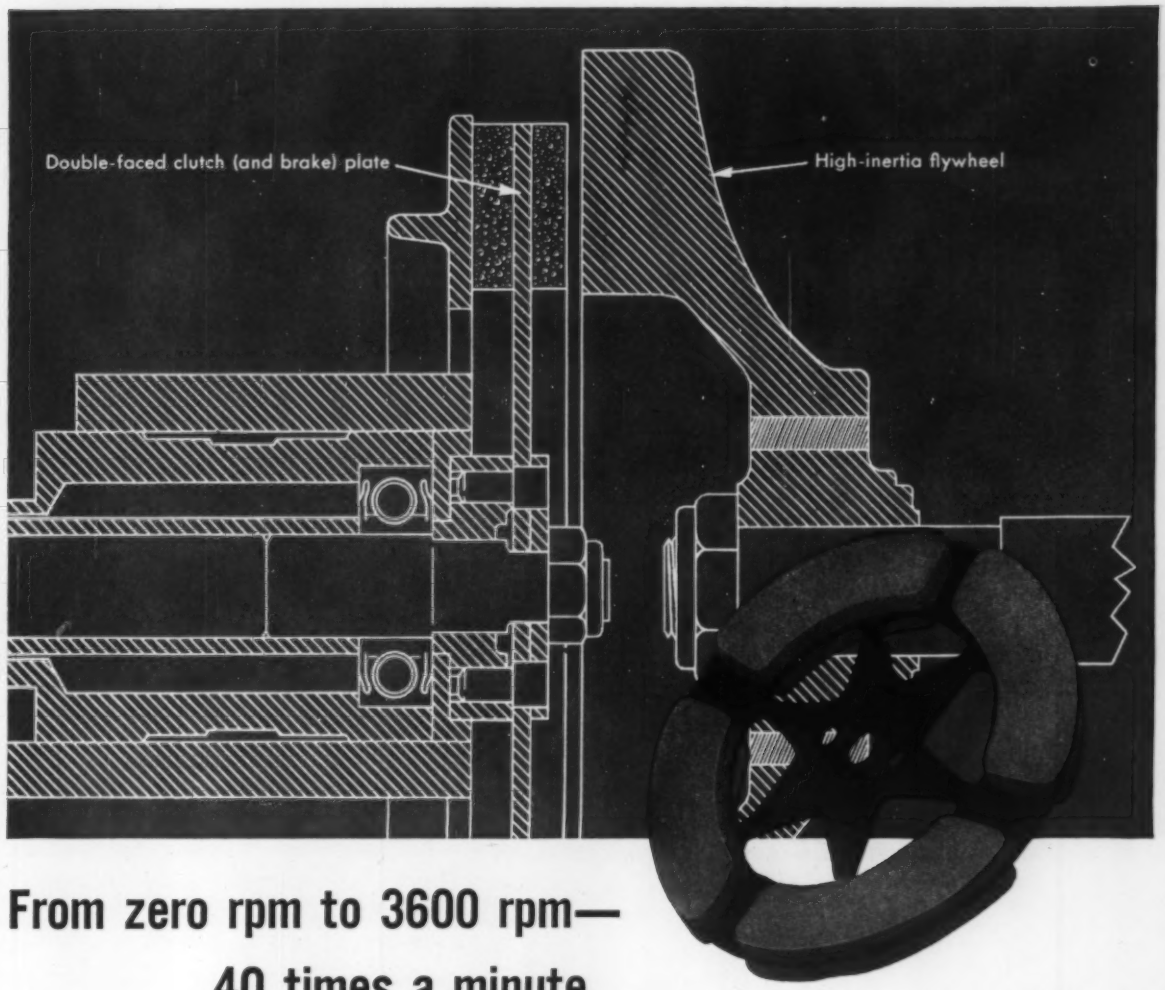
ELECTRIC MOTOR DIVISION

THE *Peerless-Electric*® COMPANY

FANS · BLOWERS · MOTORS · ELECTRONIC EQUIPMENT

1520 W. MARKET ST. · WARREN, OHIO

Circle 456 on page 19



From zero rpm to 3600 rpm— 40 times a minute

. . . a job for Armstrong friction materials

The power transmitter shown here is built to move from zero rpm to 3600 rpm in 1/10th of a second . . . as often as 40 times a minute on some applications. Yet, where necessary, it can be jogged or run at slow speeds by slipping the clutch.

Such rapid fire start-and-stop operation requires a friction material that offers virtually instantaneous engaging and braking action. The material that does the job in this transmitter is Armstrong FM-88, a new friction facing designed for dry operation.

This new material has a high coefficient of friction, enabling it to transmit torque . . . or brake it . . . instantly, in any position. This makes an ideal friction facing for such things as coil winders, tappers, reamers, industrial sewing machines, or similar equipment.

FM-88 is economical, too, both in first cost and in long life. In most applications, facings made of FM-88 will last for several millions of engagements. And this material runs quietly, too, even when the clutch is purposely slipped to get slow-speed operation.

FM-88 is one of a wide range of Armstrong resilient friction materials that are being used in both dry and wet applications in many different fields . . . including industrial equipment, office equipment, electrical appliances, machine tools, and automotive transmissions.

For more information, get in touch with your nearest Armstrong representative or write to Armstrong Cork Company, Industrial Division, 7206 Dean St., Lancaster, Pa.

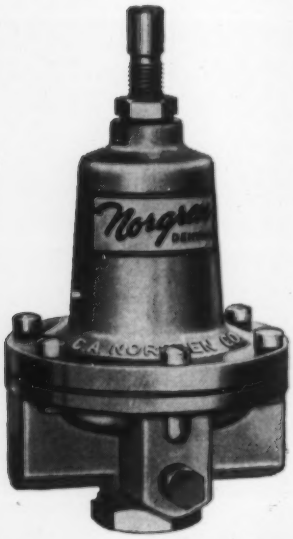
Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

Circle 457 on page 19

Protect Your Equipment from Excessive Pressure Build-Up with

Norgren RELIEF VALVES



DIAPHRAGM TYPE VALVES

Automatically Protect against damage from excessive pressure build-up. Provides controlled operation for fluid recirculating systems.

Easily Adjusted to relieve at desired pressure. Relief settings up to 250 psi for pipe sizes ⅛" to ½" inclusive, and up to 125 psi for ¾" and 1" pipe sizes.

Pop Safety Valves

Prevent the build-up of dangerous, excessive pressures in air tanks. Valve automatically pops open at desired setting. Pipe sizes ⅛" through ½".

Low Flow Relief Valves

Small, inexpensive valves suited for a wide variety of uses requiring relief at low rates of flow. ⅛" and ¼" pipe sizes.

For complete information, call your nearby Norgren Representative listed in your telephone directory...
or WRITE THE FACTORY FOR NEW NO. 800 CATALOG.

Wherever Air is Used in Industry

C. A. NORGREN CO.

3442 SO. ELATI STREET • ENGLEWOOD, COLORADO

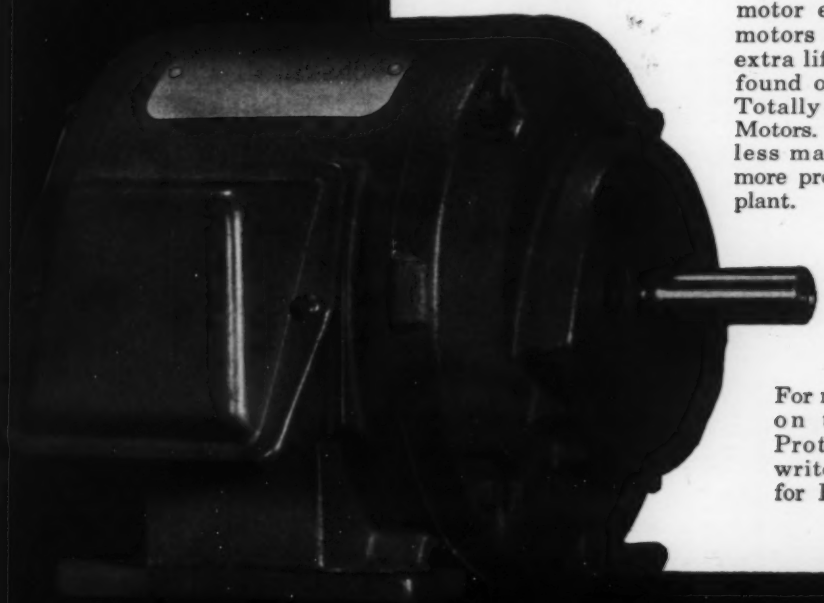
Circle 458 on page 19

TOTALLY-PROTECTED MOTOR

When we speak of Totally-Protected, we mean superior frame design with rigidity for heavy load conditions. We mean Metermatic bearing lubrication, acid and oil-proof insulation system, and motor leads, labeled and sealed in neoprene.

Totally-Protected means all this and more, but most of all it means a new concept of motor design and construction.

This Totally-Protected concept brings you a new motor efficiency. These motors have a built-in extra life—an extra life found only in Reliance Totally-Protected A-c. Motors. You profit from less maintenance and more production in your plant.



For more information on this Totally-Protected concept, write to Dept. 285A for Bulletin B-2401.

(B-1543)

RELIANCE R ELECTRIC

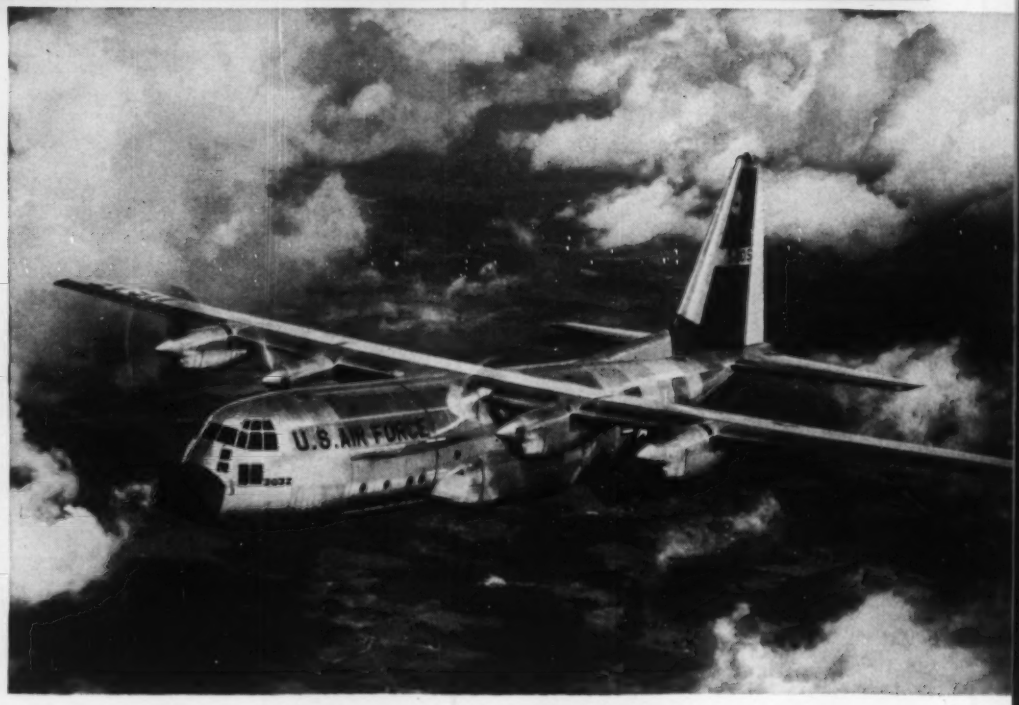
AND ENGINEERING COMPANY

CLEVELAND 17, OHIO · CANADIAN DIVISION: WELLAND, ONT.

Sales Offices and Distributors in Principal Cities

MICRO SWITCH Precision

...FIRST IN PRECISION SWITCHING



Over 200 MICRO SWITCH Precision Switches help make Lockheed's C-130 Hercules a superb military plane

Wide variety of switch types in the Hercules

Series VA Enclosed Switches
These combine the features of sealed construction and high electrical capacity. They are available with roller arm or lever actuators.

Series V3 Basic Switches
These have the highest electrical capacity for their size of any switch available. Are available in wide variety of terminal designs, contact arrangements and operating characteristics.

Series SE Sealed Subminiature Switches
These are the smallest and lightest completely environment-free precision switches available. They are built to give trouble-free operation in a temperature range of from —65°F to +212°F.

Series DT Double-Pole Double-Throw Switches
These switches simultaneously make and break two independent circuits. The double-pole double-throw switches are rated for 10 amps. 125 or 250 v ac; ½ amp. 125 v dc; ¼ amp. 250 v dc. Temperature rise limits maximum continuous current to 10 amperes per pole.

MICRO SWITCH Engineering Service cooperated with Lockheed engineers of the Georgia Division, Marietta, Ga., for five years in the designing, planning and manufacturing of this plane—the first propjet transport accepted by the U. S. Air Force.

Over 200 precision switches at strategic points perform important functions in the operation of this superb aircraft. Other MICRO SWITCH precision switches are employed in components for this plane supplied by other manufacturers. Still others provide important controls for the machine tools used in the building of the C-130 itself.

Whatever your design—be it aircraft, machine tools, or any type of industrial equipment—MICRO SWITCH components and MICRO SWITCH Engineering Service may help you make a good design even better.

MICRO SWITCH reputation for reliability, precision and performance is written in the success of such products as the Lockheed Hercules and thousands of fine industrial products. MICRO SWITCH Engineering Service is as close as your telephone. Why not call the nearest branch office today?

Switches have uses unlimited

Here's a tough switch to take the roughest going

The MICRO SWITCH sealed Type EN switch was designed to meet tough aircraft problems. Its many unusual features are now meeting many exacting industrial design requirements.

How good is this switch? Check your requirements against tests like these:

- Precise performance at minus 65°F or heated to plus 180°F. (Operating force to 20 lbs. available to facilitate ice breaking.)
- Precise performance after 100 hours in salt brine spray.
- Precise performance after hours of immersion under 36 in. head of alternating iced and heated water.
- Precise performance unaffected by 30 days' operation at 104°F and 95% humidity.
- No chattering of contacts—or loosening of parts—during vibration tests of 10 to 500 cycles per second.

(Send for Catalog No. 77)

Hermetically sealed basic switch insures constant performance

This small MICRO SWITCH Type HS precision switch is truly hermetically sealed (glass to metal and metal to metal) to insure constant operating characteristics under any environmental conditions—for example, no condensation problem.

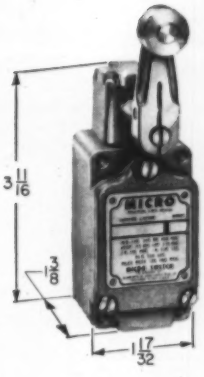
The switch shown has a lever type actuator for inline motion operation. The switch is also available with a roller-lever actuator suitable for actuation by cams, slides or other mechanical means.

Characteristics of Switch Shown

Operating force—10 to 22 oz.; Release force—4 oz. min.; Overtravel—.010 min.; Differential travel—.020 in. max.; Weight—1.5 oz.

Electrical Characteristics—28 volts dc—inductive 10 amperes; resistive 25 amperes; 125 volts ac—inductive 1 ampere; resistive 1 ampere, (Send for Catalog No. 77)

Sealed—Reliable—Versatile—Give millions of operations



The MICRO SWITCH Type LS is a small two-circuit switch which meets a wide variety of industrial design requirements. It is extremely reliable, ruggedly housed and can be mounted in almost any location. Actuator head may be removed in the field and rotated to permit actuation from any of the four quadrants. The roller-arm actuator is field adjustable through 360°. It may operate in either direction, or one direction only.

The electrical rating is: 10 amperes 120, 240 or 480 volts ac; ½ H.P. 120 volts ac; 1 H.P. 240 volts ac; .8 ampere 115 volts dc; .4 ampere 230 volts dc; .1 ampere 550 volts dc. Pilot duty rating is 600 volts ac maximum.

(Complete information in Catalog 83)

MICRO SWITCH, a Division of Honeywell, pioneered the manufacture and development of precision snap-action switches

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

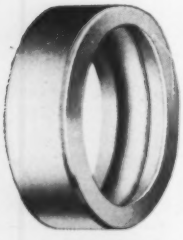
Circle 460 on page 19

~~ABEC-5~~

ABEC-7

Now...every bearing you buy from New Hampshire Ball Bearings, Inc., meets ***CLASS 7 STANDARDS****...automatically... at no increase in price...with no special selection or specification required!*

INNER RING



OUTER RING

ABEC-7 TOLERANCES

MEASUREMENT	TOLERANCE
Bore	+ .00000" − .00015"
Width (Individual Rings)	+ .000" − .005"*
Radial Runout (TIR) Max.	.0001"
Parallelism of Sides	.0001"
Side Runout with Bore	.0001"
Groove Parallelism with Side	.0001"
O. D.	+ .00000" − .00015"
Width (Individual Rings)	+ .000" − .005"*
Radial Runout (TIR) Max.	.0001"
Parallelism of Sides	.0001"
O. D. Runout with Side	.00015"
Groove Parallelism with Side	.0002"

**Width tolerance for MICRO bearings is + .000" − .001"*

Commonly obtainable standards of precision in the miniature bearing industry start at ABEC-5 and the highest refinement is reached with ABEC-7.

Continued advances in our techniques and controls have enabled us to standardize all production of Micro-Bearings at this highest quality level.

NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH, NEW HAMPSHIRE

Circle 461 on page 19

The performance and the name are the same around the world

MACHINERY MANUFACTURERS:

The performance of Shell Alvania Grease enjoyed by your domestic customers is available abroad. And this same uniformity applies to

SHELL TURBO OIL—gives anti-wear lubrication for utility, industrial and marine turbines

SHELL TELLUS OIL—lubricant and control fluid for complex hydraulic systems, and a complete line of other

SHELL INDUSTRIAL LUBRICANTS

Shell Alvania Grease, used world-wide as a multi-purpose lubricant, has an outstanding performance record in solving many of the toughest anti-friction bearing grease problems. Ideal for wet, humid applications (inhibited to prevent water corrosion), it lubricates under water-wet conditions which normally spell trouble.

Alvania* Grease has the added advantage of remaining plastic in sub-zero weather and stable under sustaining high temperatures. This one grease successfully replaces dozens of special lubricants in plant after plant . . . reason enough for its universal popularity. For complete information, write Shell Oil Company, 50 West 50th St., New York 20, N. Y., or 100 Bush St., San Francisco 6, Calif.

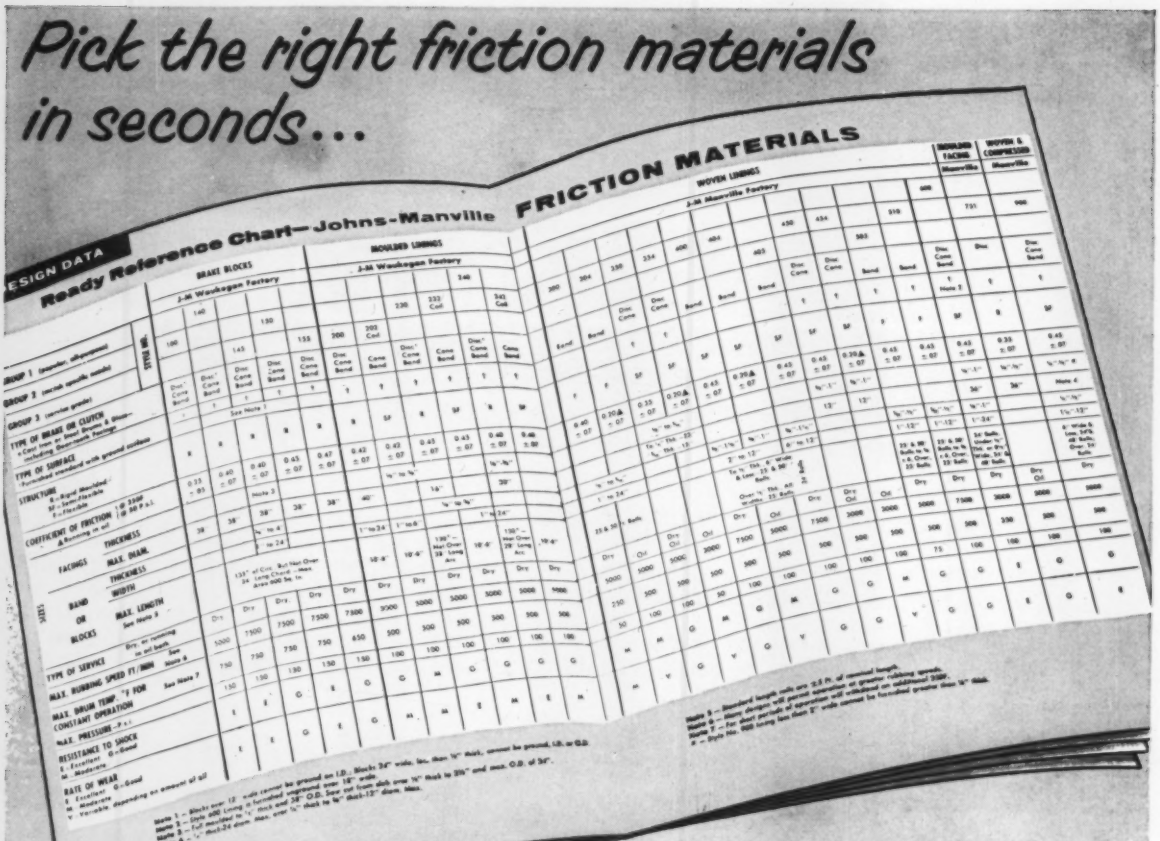
*Trademark

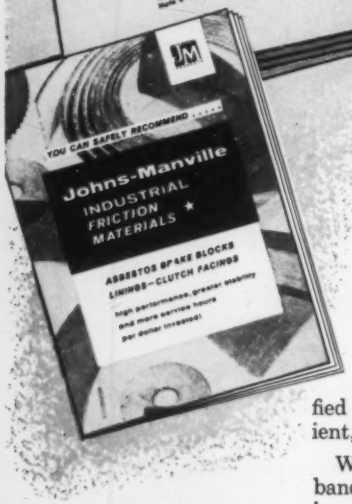
SHELL ALVANIA GREASE

A TRULY MULTI-PURPOSE LUBRICANT

SHELL

Pick the right friction materials in seconds...





It's in Johns-Manville's handy new Friction Materials Selector

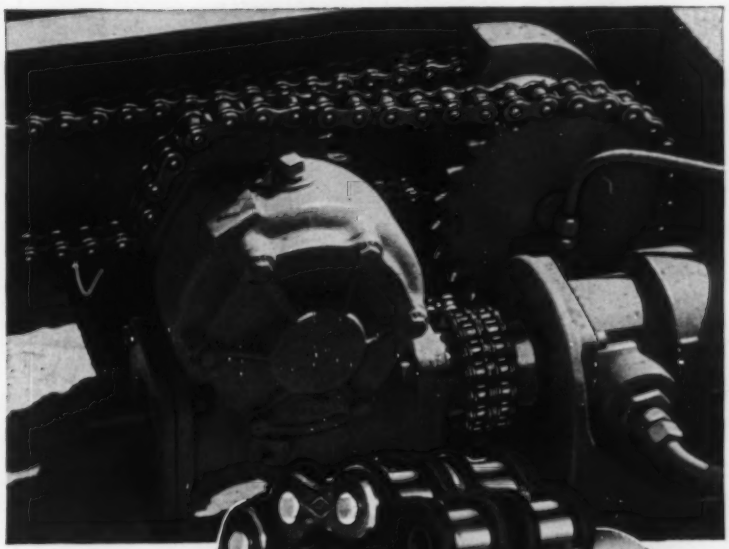
WHEN YOU ENCOUNTER a design problem that involves the control of motion, you'll find this new, ready-reference book about Johns-Manville Friction Materials a big help. Its sixteen pages are loaded with specific design data, presented in simplified table form, that you'll find convenient, accurate and easy to use.

Whether you require a disc, cone, band, block or lining—for application in wet or dry service, heavy or light duty, slow or high speed operation, light or heavy pressure—this book will give you performance characteristics, available sizes and shapes, dimension data and tolerances.

Whatever your problem dealing with the control of motion the J-M Friction Material specialist . . . backed by unmatched J-M Research facilities . . . is at your service. Write Johns-Manville, Box 14, New York 16, N.Y., for your free copy of the Friction Materials Guide—FM35A. *In Canada, Port Credit, Ont.*

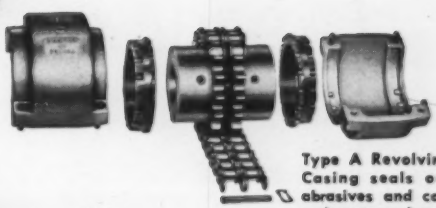
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville *Industrial* FRICTION MATERIALS



DIAMOND FLEXIBLE COUPLINGS *IN STOCK* AT YOUR DIAMOND DISTRIBUTOR

DIAMOND



Type A Revolving Casing seals out abrasives and corrosive atmospheres, seals in lubricant for extended coupling life.

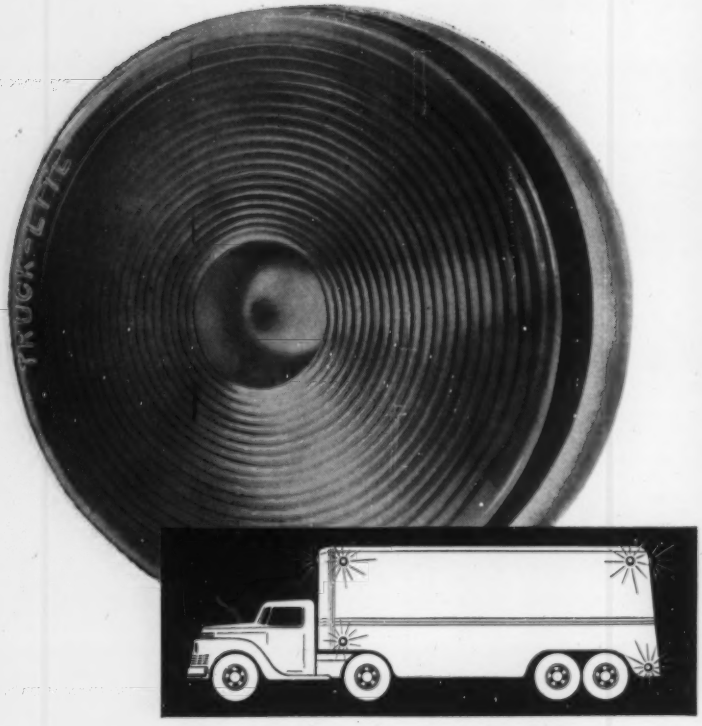
End to end shaft connections can be made quickly, inexpensively and in minimum space with Diamond Flexible Couplings. Load is carried at the greatest radius and distributed evenly over the entire length of chain for maximum capacity and life. Moderate angular and parallel misalignment as well as shaft end float are absorbed in the clearances between chain and sprocket teeth.

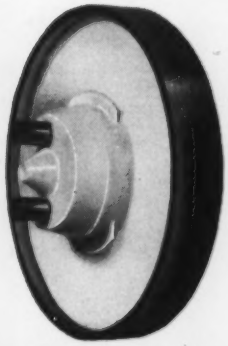
You probably have many applications for Diamond Flexible Couplings. Call your nearest Diamond Distributor for immediate service. His name is in the yellow pages of the telephone book under the heading Chains or Chains-Roller.

DIAMOND CHAIN COMPANY, Inc.
Dept. 435, 402 Kentucky Ave., Indianapolis 7, Ind.
Offices and Distributors in All Principal Cities

DIAMOND ROLLER CHAINS

Circle 464 on page 19





Rear Views showing Bulb Holders in Flush Mounted and Face Mounted Lamps

Truck-Lite created a

bright new idea in truck lighting

—Sylvania custom molded it

Truck-Lite's new all plastic, sealed, "throwaway" lamp unit is a light-saving, maintenance-saving idea in truck clearance and marker lamps.

Its rustproof, shatterproof plastic lens was designed by Truck-Lite and Sylvania for brilliant wide-angle illumination. Throwaway feature combined with simple plug-in receptacle is a boon to truck-light maintenance.

Custom molding of intricate parts like the Truck-Lite lens and bulb holders is just one of the reasons leading manufacturers, large and small, come to Sylvania for consultation on parts designs.

Sylvania's Parts Division also offers complete facilities for custom metal stampings, special electronic components and special wires. For complete details of these services, write for the "Portfolio of 4-way Service to Designers."

The *Truck-Lite* lens is molded of heat-resistant methacrylate in red, green, amber and crystal. The angle of its refraction prisms (a) are molded in graduations of 1° to produce controlled illumination over a full range of 180°.

Mounting surface of the lens (b) is held to ±.002″ to insure proper seating of bulb holder and accurate positioning of the light with respect to the truck body.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

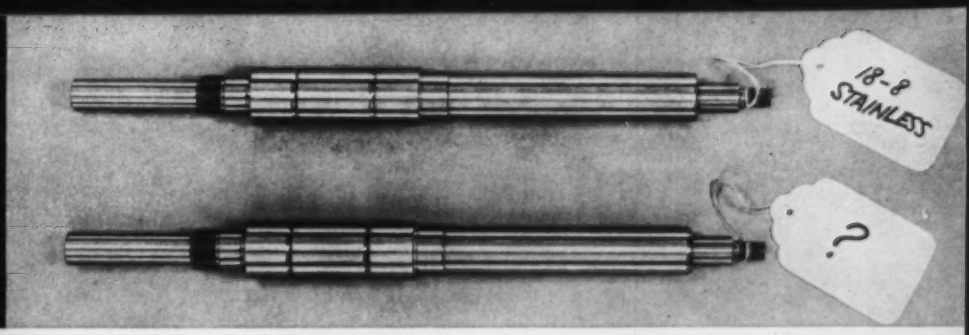
LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

SPECIAL WIRE | METAL STAMPINGS | MOLDED PLASTIC | ELECTRONIC COMPONENTS

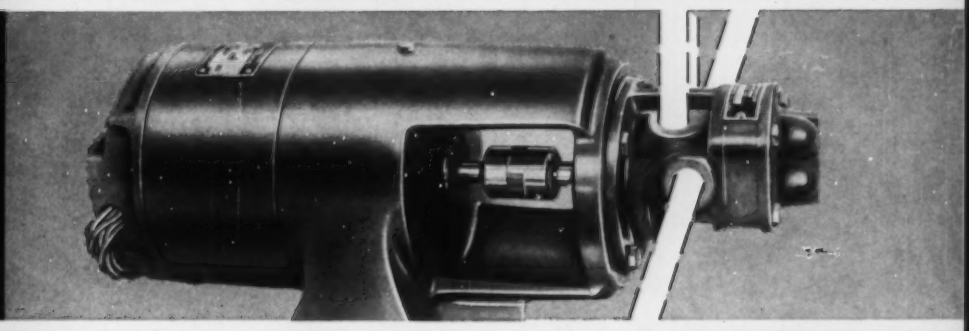
4-way service from one source

Circle 465 on page 19

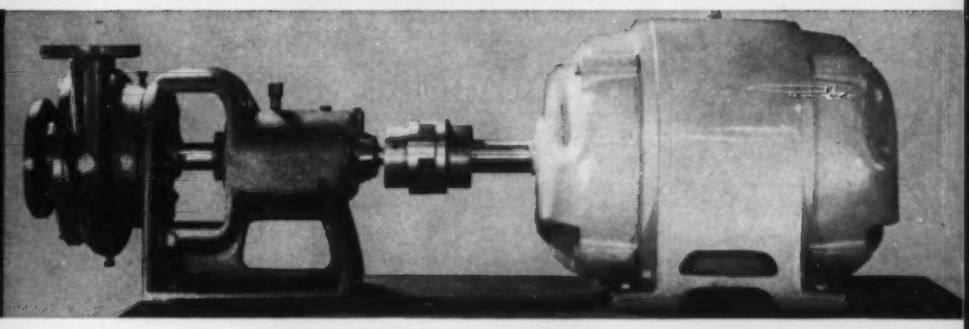
1. What's more "stainless" than "stainless steel"?



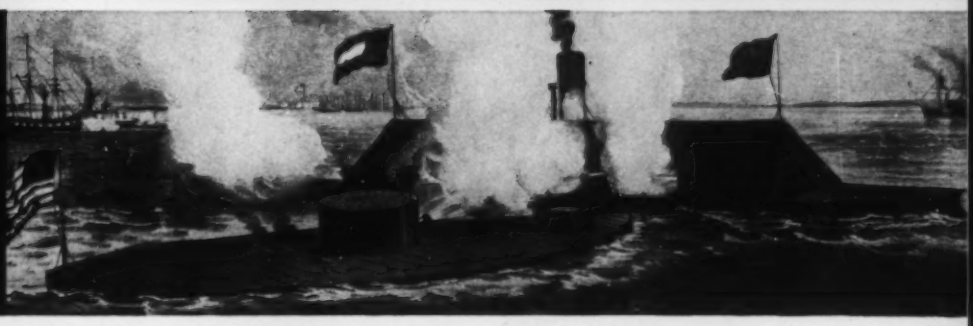
2. What's the newest in rotary pump hook-ups?



3. It comes in 70,480 combinations. Can you name the line?



4. Whose pumps would you have found in the Merrimac? Monitor?



WHAT'S YOUR P.Q.? (PUMP QUOTIENT)

1. *Answer:* Worthite*. Worthite is Worthington's super stainless steel for chemical pumps. Containing over 50% more alloy than 18-8 stainless, Worthite gives one third greater corrosion coverage for just a few cents more per pound. Bulletin W-350-B4 has complete details about Worthite.

2. Dual suction and discharge openings are the newest idea in rotary pumps. Available on the new Worthington Monobloc Rotary, they allow a choice of 28 different piping arrangements. In addition to simplified hook-ups, the new Worthington Monobloc Rotaries have many new convenience features such as standardized flange and shaft diameters to eliminate alignment. Flexible coupling allows rapid pump replacement without disturbing motor. For more information write for Bulletin W-484-B1.

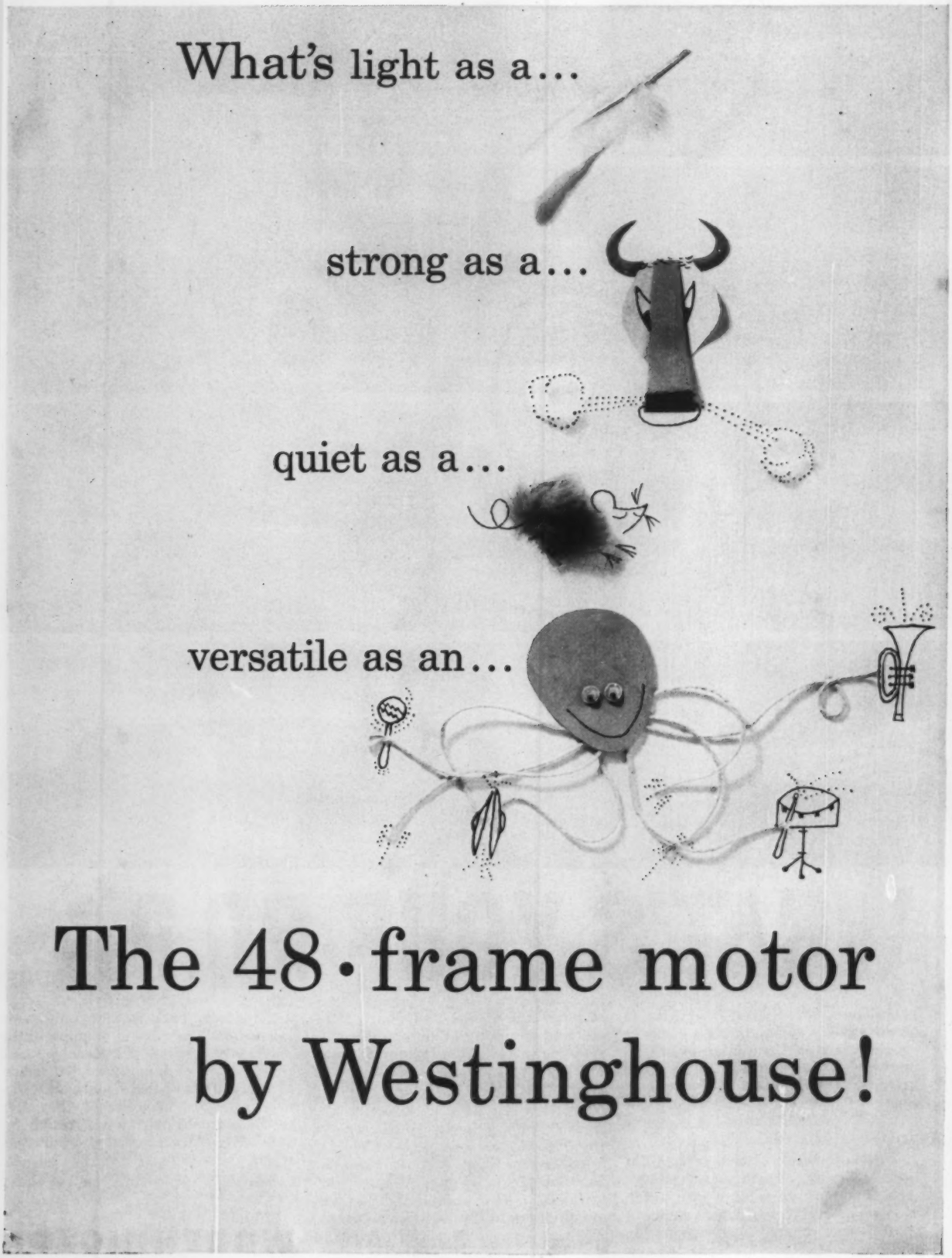
3. The pump you see is just one of the 70,480 combinations available in Worthington SESC line. An abbreviation for "Standard End Suction Centrifugal," SESC pumps are the most versatile, most flexible you can buy. They give you a choice of 5 types of liquid ends, 4 materials of construction, 2 shaft sealing methods and 5 different drives. Write for Bulletin W-300-B4.

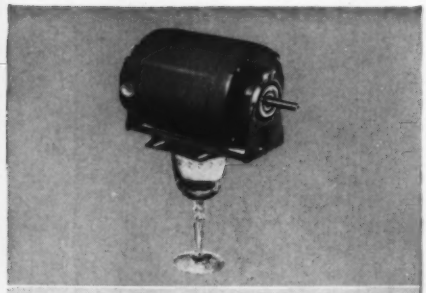
4. Even way back in 1862, engineers appreciated the value of pumps built by Worthington. Both the Merrimac *and* the Monitor were equipped with Worthington pumps. Today as then, whenever men must move liquid, they turn to the company with a reputation for reliability. Worthington Corporation, Harrison, New Jersey. PC. 7.14

*A high nickel, high-chromium, corrosion resistant alloy steel. Trademark Reg. U. S. Pat. Off.

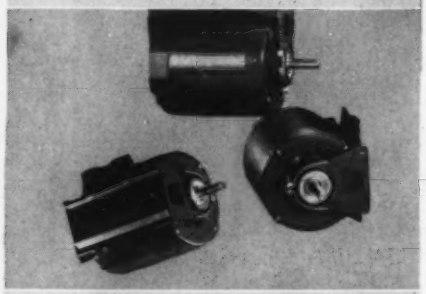
WORTHINGTON

Circle 466 on page 19

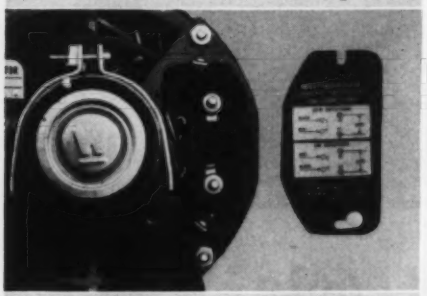

What's light as a...
strong as a...
quiet as a...
versatile as an...
The 48·frame motor
by Westinghouse!



Light as a feather . . . by up to 50%!



Powerful . . . mounted in any position!



Versatile . . . modern terminal board!

Easy to mount . . . threaded conduit hole!

Dependable . . . because it's Westinghouse!

What do you look for in an FHP Motor?

Whether you are a manufacturer, designer, buyer or engineer, there are certain features you look for when you buy fhp motors. You want a motor that is light . . . powerful . . . compact . . . quiet . . . and long lasting.

These are just a few of the features you get in 48-frame motors by Westinghouse! Feature by feature, there are no finer motors on the market! Don't take our word for it . . . compare. Here are the facts . .

Fact 1: The Westinghouse 48-frame is up to 50% *lighter* than motors of comparable power! For *you* this means lighter equipment, reduced shipping costs.

Fact 2: The Westinghouse 48-frame gives you *true* all-position mounting. Positive oil return system provides excellent lubrication in any position.

Fact 3: The Westinghouse 48-frame gives you spade mounting (plug-in), standard terminal stud connections, and shur-plug for changing rotation.

Fact 4: The Westinghouse 48-frame threaded conduit hole assures faster assembly on your production lines, fewer connector parts and *positive* connections.

Fact 5: The Westinghouse 48-frame *is Westinghouse!* This distinctive tag is your guarantee of quality, performance, and long life.

Want More Facts? Call your nearest Westinghouse sales engineer, or get your copy of the 48-frame booklet giving all the features in detail. Just fill out and mail this coupon . . . J-03034

YOU CAN BE SURE . . . IF IT'S

Westinghouse

Small Motor Division, Lima, Ohio.

WESTINGHOUSE ELECTRIC CORPORATION
Small Motor Division, P. O. Box 566
Lima, Ohio

Send me your 48-frame booklet.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Circle 467 on page 19

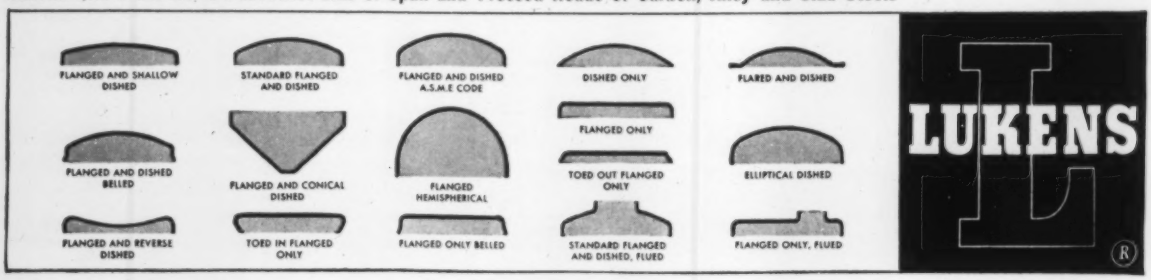
In this Norton Grinder, imaginative designing with Lukens heads simplified construction, saved money.

Improve your product... cut costs... designing with Lukens heads

■ Start to think about simplifying *your* designs, even redesigning, with Lukens standard head shapes. For Norton Company, Worcester, Mass., this led to stronger and safer grinding-wheel guards on machines such as this Type U-4 Universal Grinder—plus positive savings in cost and time. Two standard Lukens heads fitted together turned the trick.

Where can preformed Lukens heads reduce design complexity and eliminate fabricating steps in your equipment? Put your imagination to work and see. Others have used them in wheels, valves, chemical equipment, heavy and light machinery. Lukens' fifty-five years as the leading producer of spun and pressed steel heads for many applications are at your service. Write for Catalog 935, *"Pricing and Engineering Data."* Lukens Steel Company, Coatesville, Pennsylvania.

Lukens Offers the World's Broadest Line of Spun and Pressed Heads of Carbon, Alloy and Clad Steels



Circle 468 on page 19

Which Type ADJUSTABLE SPEED DRIVE CONTROL Do You Need? SQUARE D BUILDS BOTH!

Typical application of Adjustable Voltage Drive to large metal spinning lathe in operation at Phoenix Products Company, Milwaukee

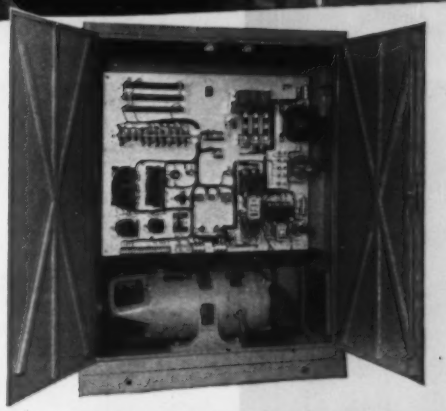
ADJUSTABLE VOLTAGE CONTROL FOR M-G SETS...Through 400 HP

Simplified Circuits with rugged heavy-duty control components.

Easy Maintenance because standard magnetic starters, relays and timers are used in combination with static regulators.

3 Types Available • (*1*) magnetic amplifier exciters (*2*) dry disc exciters (*3*) rotating exciters.

Easy to Adjust because centralized "tune-up" elements are accessible and readily identified.



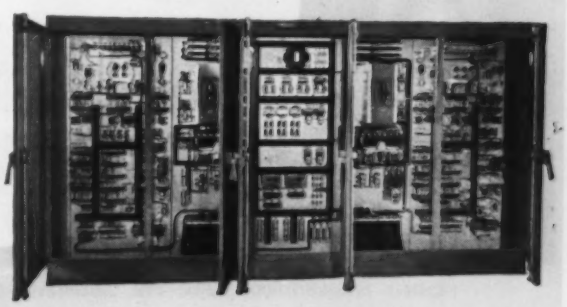
FULLY ELECTRONIC with SIMPLIFIED FAIL-SAFE CIRCUITS THROUGHOUT

Simplified Circuits use less tubes. Fail-safe circuits prevent motor runaways.

Easy Maintenance because sub-panels can be quickly removed and replaced. "Brain" panel senses varying conditions.

Easy to Adjust with only a few, very accessible potentiometers.

Both types are available in two kinds of construction—standard package and custom-built.



Write for descriptive literature. Address Square D Company, 4041 North Richards St., Milwaukee 12, Wis.

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

Circle 469 on page 19

Dayton Variable Speed Cog-Belts* make possible Unique Drive for New 1957 RCA WHIRLPOOL Washer-Dryer Combination

Whirlpool Corporation turned to Dayton with a revolutionary new drive design for their RCA WHIRLPOOL Washer-Dryer Combination. What they proposed was a variable speed V-Belt transmission to replace the conventional gear case. Potential benefits to users of the Washer-Dryer Combination was a smoother, more readily adjusted, quieter running drive, and lower operating costs.

Dayton V-Belt Engineers analyzed the design, then recommended Dayton Variable Speed Cog-Belts* and furnished samples for initial testing. These first tests proved that the design would work and that the specially designed Dayton Cog-Belts were non-dusting, flexible enough to work over small diameter sheaves, and would pick up the load smoothly and without slipping.

From then on, engineers for both Dayton and Whirlpool worked as a team through the design, redesign and production design stages with Dayton furnishing new samples at each stage. Not only was the design perfected through this coordinated activity but it was mechanically simplified and its cost reduced.

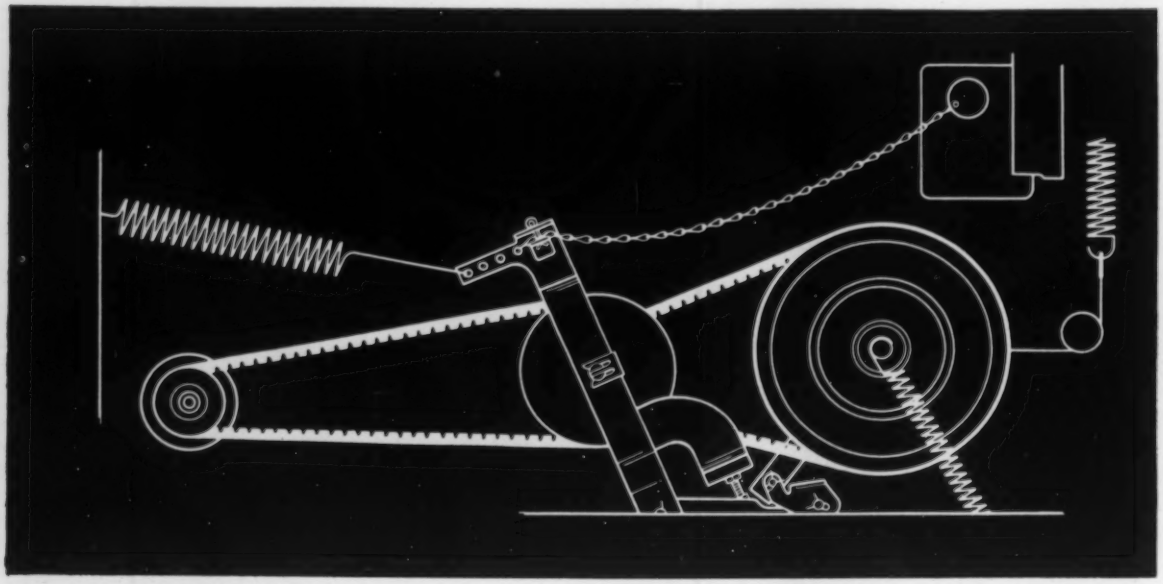


FIGURE 1—RCA WHIRLPOOL Washer-Dryer Combination with back panel removed showing variable speed drive controls.

The final design, now in production, (Fig. 1) employs a simple, single-speed motor to drive the cylinder at both tumble and spin speeds and completely eliminates the conventional geared transmission. Essentially, the drive is composed of a unique variable speed sheave assembly and two plate-finished Dayton Variable Speed Cog-Belts.

The sheave assembly (Fig. 2) has a sliding center section, and is mounted in a pivoted bracket. Movement of the bracket, and control of the speed ratio, is through a speed control motor connected to the bracket by a chain.

During all wash, rinse and tumbling cycles (Fig. 3), the sheave assembly is held in low drive by a pull-back spring.

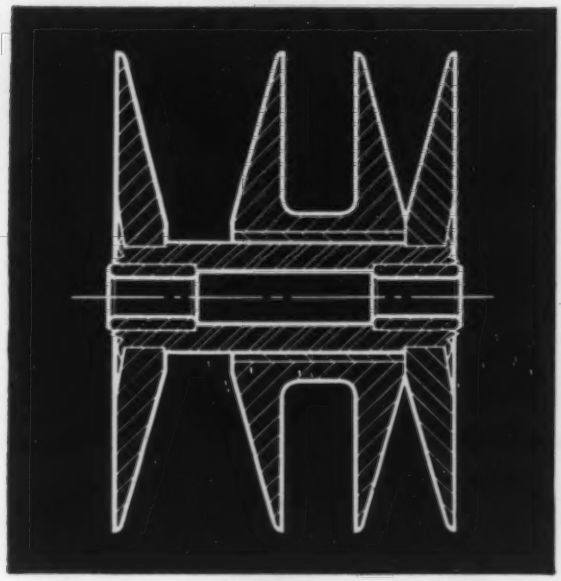


FIGURE 2
Exploded view of variable speed sheave assembly.

Cylinder speed during the low drive cycles is 45 rpm.

During the spin-dry cycle (Fig. 4), the speed control motor is actuated and, by taking-up the linking chain, causes the bracket to pivot. As the bracket moves, tension is increased on the primary belt and decreased on the secondary belt, causing the center section to move sideways. As tension is equalized by the movement of the center section of the sheave, the primary belt pulls deeper into the sheave and the secondary belt is forced away from the sheave axis. The ratio change thus effected produces a resultant speed of 200 rpm.

Another tremendous advantage of the design is that it is infinitely variable within the assigned limits. Thus, it is possible, by the addition of a delayed-reset switch and a simple control arm, to interrupt the speed change at any point, if vibration is created by an out-of-balance load. The result is positive, automatic load balancing.

Here is how this feature operates. When an excessive out-of-balance condition exists, the excursion switch arm trips the excursion switch. This breaks the circuit to the speed control motor for approximately 13 seconds — during which time the pull-back spring returns the drive to tumble speed and the load redistributes itself. When 13 seconds have elapsed, the switch automatically resets and the drive again shifts into the high range. If necessary, there can be unlimited "hunting" for a balanced condition before the cylinder reaches 200 rpm, the normal spin-dry speed.

While complex and difficult to describe, the load balancing operation is so smooth that it is hardly perceptible. This is due to the special design and construction of Dayton Raw-Edge Cog-Belts.

Dayton's experienced Engineers are ready to assist you in solving your special V-Belt design problems. To contact them, or for more information about Dayton Raw-Edge V-Belts, write The Dayton Rubber Company, Industrial O.E.M. Division, Dayton 1, Ohio.

FIGURE 3
Variable speed drive during tumble cycle. Cylinder speed is 45 rpm.

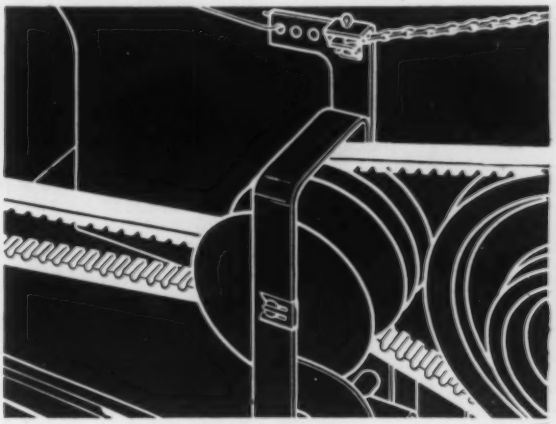


FIGURE 4
Variable speed drive during spin cycle. Cylinder speed is 200 rpm.

THE DAYTON RUBBER COMPANY, INDUSTRIAL O. E. M. DIVISION, DAYTON 1, OHIO

Dayton Rubber

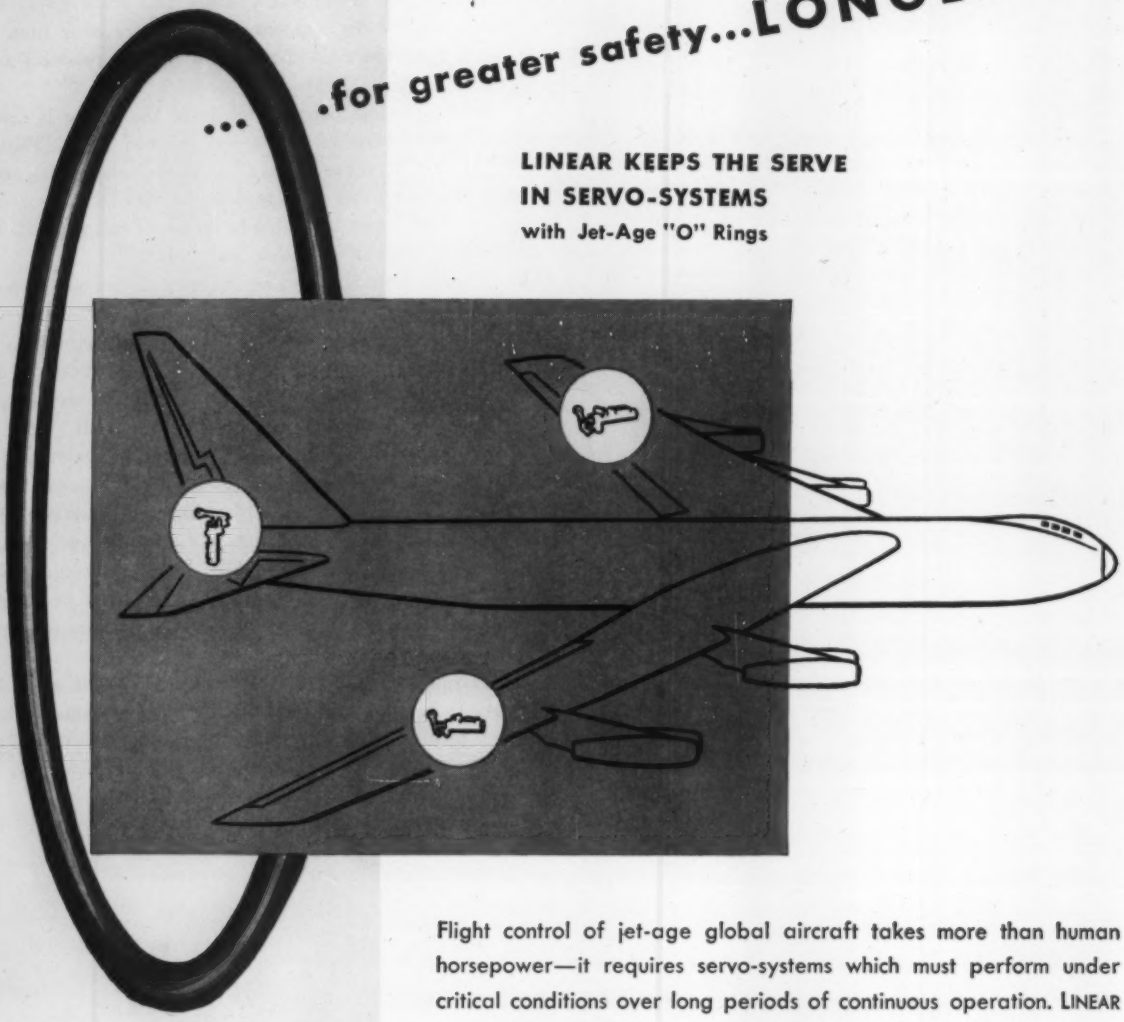
©D.R. 1957 *T.M.

WORLD'S LARGEST MANUFACTURER OF V-BELTS

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, E. Moline, New York, Rock Island, San Francisco and St. Louis.

...for greater safety...LONGER

LINEAR KEEPS THE SERVE IN SERVO-SYSTEMS
with Jet-Age "O" Rings



Flight control of jet-age global aircraft takes more than human horsepower—it requires servo-systems which must perform under critical conditions over long periods of continuous operation. LINEAR has developed "O" rings and seals that keep the serve in servo-systems—to keep these planes in the air longer—safely.

For these critical requirements, LINEAR developed precision "O" rings molded of the newest elastomers to meet the most rigid specifications. They will withstand temperatures of from −130° to 550°F —give long service life under severe mechanical abuse—and will withstand the destructive action of such fluids as silicate and phosphate esters, hydrocarbons and synthetic lubricants.

When it's a sealing problem, call on LINEAR or one of its agents for engineering assistance...
and be sure to specify LINEAR "O" Rings.

"PERFECTION IN RUBBER"
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 471 on page 19

New Gisholt 30 H.P. Turret Lathe features a compact, integrated headstock, bedframe design. Nickel alloyed components help keep the 12-speed unit running smoothly... dependably at top performance. Produced by Gisholt Machine Co., Madison, Wisconsin.

Gisholt depends on nickel alloy steels for highly stressed parts in new saddle-type turret lathes

In Chuck Screws—carburized type 3312 nickel chromium steels with wear resistance plus a tough case to prevent thread chipping, and a strong core to carry heavy torsional loads.

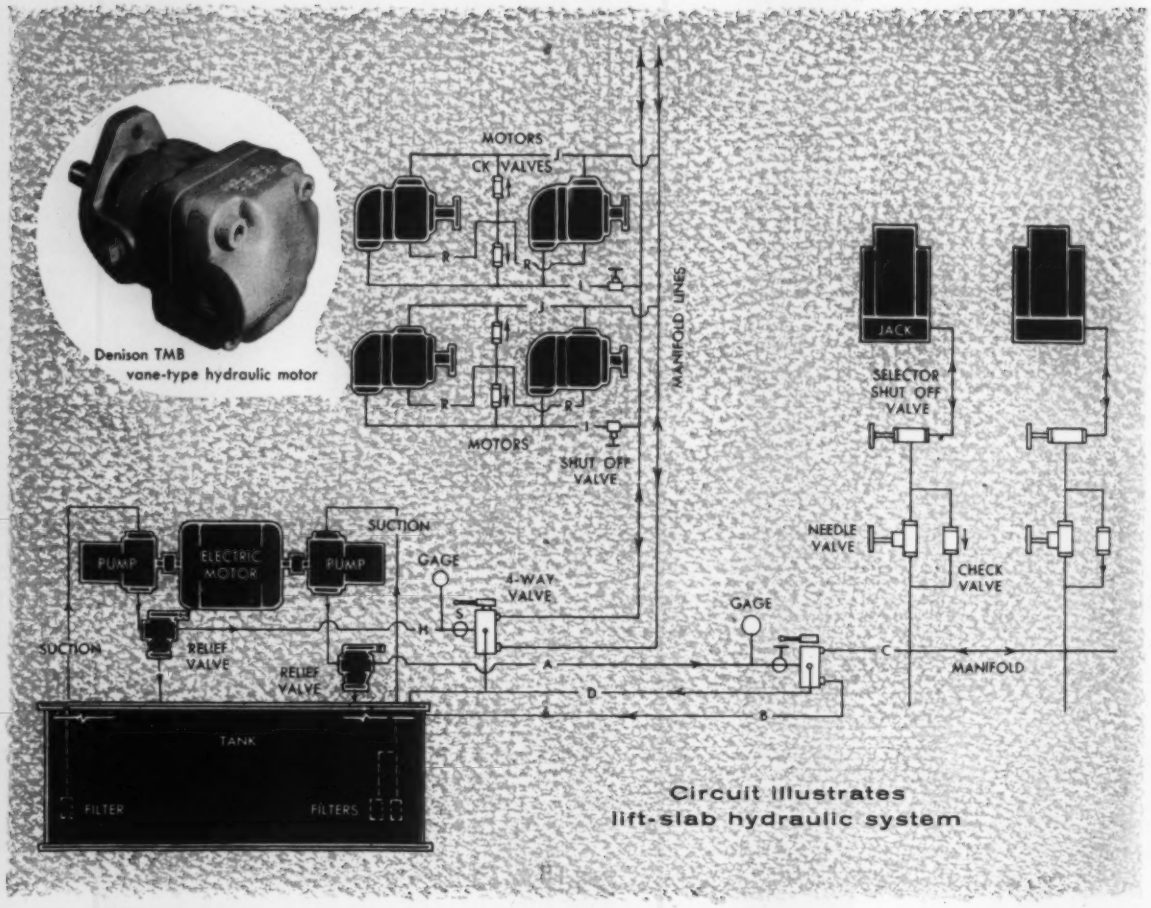
In Certain Headstock Gears—type 4620 Ni-Mo case-hardened to provide wear resistance and strength with a minimum of distortion during heat-treatment.

In Drive Pinions for Hexagon Turret Saddles—where 4340 Ni-Cr-Mo steel quenched and tempered to 40-45 Rc has proved its uniformity and reliability through years of service.

Three problem parts! Three practical solutions for Gisholt! All proved... with nickel alloy steels. What about critical metal parts in *your* products?

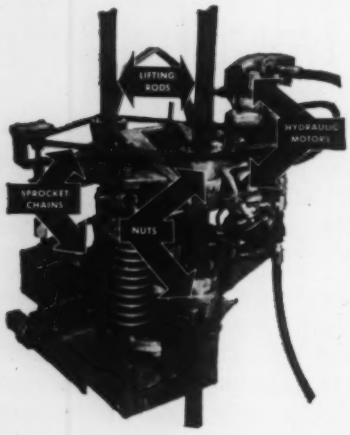
Chances are, too, that solutions to the problems they present lie in the outstanding combinations of properties available from steels containing nickel. Why not take advantage of Inco's available knowledge of the capabilities of nickel steels. Send us the details of your problem, and we will be glad to suggest possible solutions.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N.Y.



Helping to raise the roof

...another application for Denison hydraulic power



Lifting jack used in this operation can raise slabs 4 feet per hour. Nuts are turned by sprocket chains actuated by Denison hydraulic motors.

Since the first lift-slab building was erected in 1950, the interest and demand for this method of construction has increased to such an extent that lifting 500-ton slabs of concrete into the air hydraulically is now an everyday occurrence.

The lifting equipment consists of a series of hydraulic jacks operated from a console. Two Denison hydraulic motors on each lifting jack are used to actuate sprocket chains which turn nuts on threaded lifting rods and follow up the lifting action of the jacks.

Dependable, easily controlled hydraulic power assures a virtually foolproof operation.

This unique application illustrates one of many potential uses for hydraulic power. When designing any type of equipment or machinery, consult a hydraulic specialist. Write Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.

HYDRAULIC PRESSES • PUMPS
• MOTORS • CONTROLS

DENISON HydrOILics

Circle 472 on page 19

HERE'S self-alignment

IN A STEEL HOUSING

HOW "MILL BEARINGS" MAINTAIN ALIGNMENT. Spherical inner ring is free to align in any direction. Full load capacity is assured regardless of shaft deflection or misalignment.

"Mill Bearings" are available for shafts up to 11 inches.

SUPER-RUGGED CAST STEEL HOUSING. Cap is anchored solidly by extra large dowels and four heat-treated thru-bolts with serrated steel nuts.

LINK-BELT "Mill Bearings" with steel housings compensate for inaccuracies of welded and concrete support structures

HERE's one bearing really built to take the grind and grime of heavy loads in steel mills, mines, foundries and other extra-severe applications. The self-aligning Link-Belt "Mill Bearings" with cast steel housing adjust for misalignment of shafts and support structures. Furthermore, it eliminates the need for extra heavy shafting to avoid deflections which are ruinous to ordinary bearings.

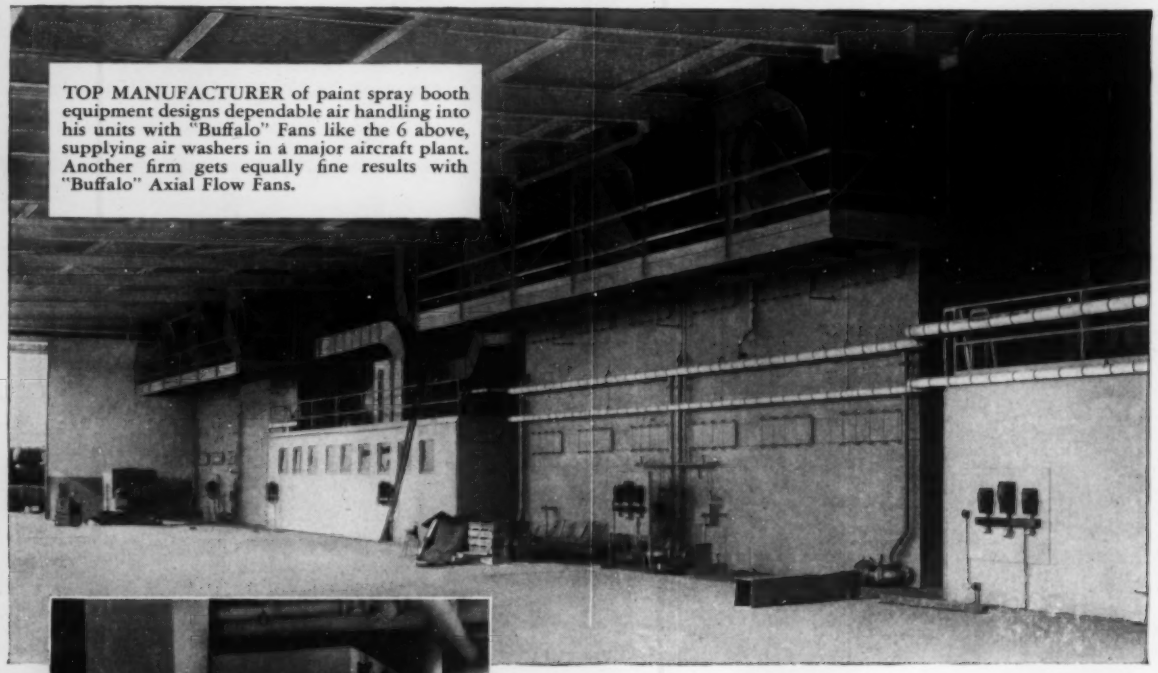
This bearing is effectively sealed, self-contained, factory-adjusted—needs no shims or alignment rings at installation. Get full facts in Book 2565A . . . or Book 2550, which covers industry's most complete line of self-aligning ball and roller bearing blocks. Ask any of the 40 Link-Belt offices. 14,442-A

LINK-BELT

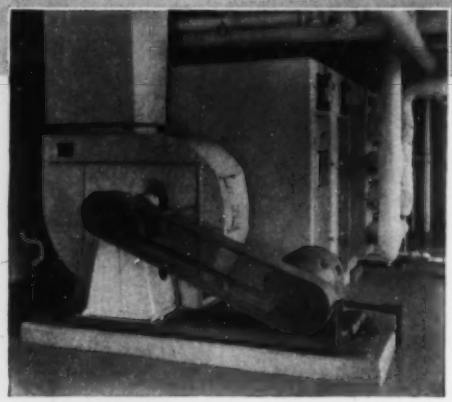
self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

IF THERE'S A FAN IN YOUR PRODUCT

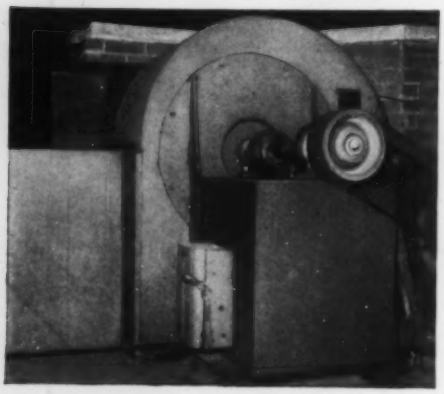


TOP MANUFACTURER of paint spray booth equipment designs dependable air handling into his units with "Buffalo" Fans like the 6 above, supplying air washers in a major aircraft plant. Another firm gets equally fine results with "Buffalo" Axial Flow Fans.



IN THE COUNTRY'S NO. 1 AIR CONDITIONING installations, you'll often find "Buffalo" Type "BL" Fans distributing the air.

LEADING BUILDER of tunnel kilns insures continuous top performance and long life with "Buffalo" Propeller and Centrifugal Fans.



MAKE IT "BUFFALO" FOR BEST RESULTS

For years, manufacturers of equipment embodying fans have relied on "Buffalo" for the efficiency and durability so necessary to successful performance of their equipment. You'll find everything from small "Buffalo" Blowers and Exhausters to high-capacity Type "BL" Centrifugal Fans serving equipment everywhere and serving it well.

First, "Buffalo" fanmanship, developed through 80 years in the business, means fan construction you can count on.

Second, the "Buffalo" line is complete. You can select the exact type and size to fit your product design — propeller fans, axial flow fans, centrifugal fans. And "Buffalo" has facilities to supply you with special designs to meet your most particular requirements. A talk with your nearby "Buffalo" Engineering Representative will bring out the proper fan to design into your product for results that make sales and reputation for you.

BUFFALO FORGE COMPANY

BUFFALO, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

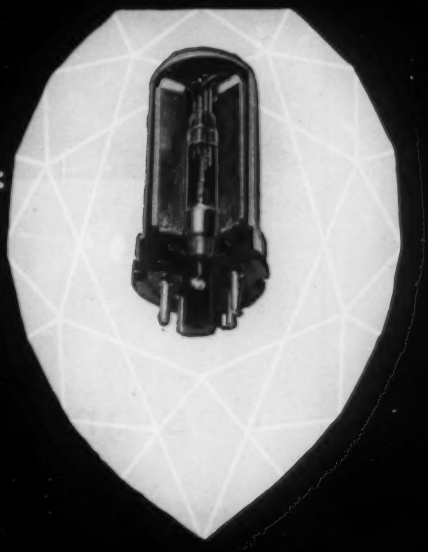
"Buffalo"

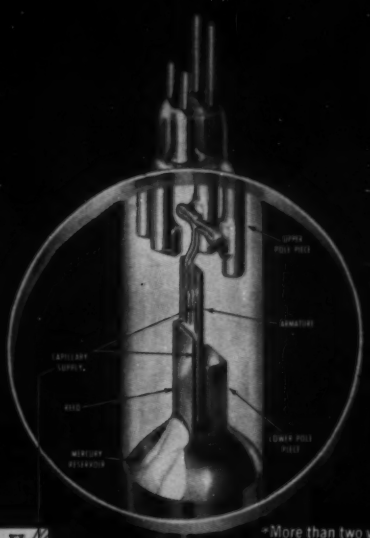
VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING
FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Circle 474 on page 19

Circle 475 on page 19→

THIS CLARE RELAY IS *practically* FOREVER*





In many applications the right kind of relay will outlast and outperform any other circuit elements.

Even the most eager advocates of static switching systems—where static-magnetic and solid-state elements are used to accomplish functions usually performed by relays and other contact-making devices—now recognize this fact.

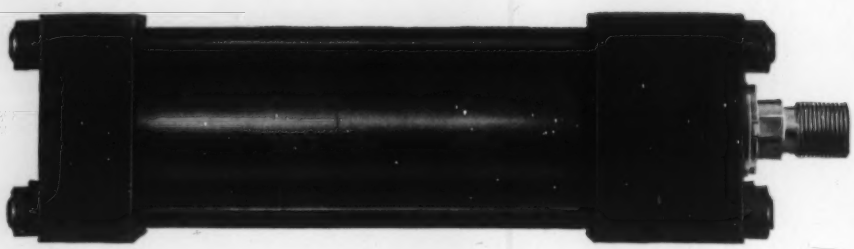
The Clare Mercury-Wetted-Contact Relay, for example, has a life of billions* of faultless operations. It requires no maintenance. It can switch from 250 volt-amperes down to a faint whisper of voltage and current. It is the best dry circuit relay in existence. More than that—it is completely free from contact bounce.

THIS is the relay that has become the main reliance of hundreds of leading designers of computing, data-processing and control equipment. For complete information write for Bulletins 120 and 122, C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: 659 Bayview Avenue, Toronto 17. Cable Address: CLARELAY.

CLARE RELAYS

FIRST in the industrial field

*More than two years ago a life test was started on a group of these relays carrying a full contact load of 5 amperes at 50 volts d-c with suitable spark suppression. They have been operating continuously ever since at 5,184,000 operations a day. They are now approaching the 4-billion mark... and the end is not yet in sight.



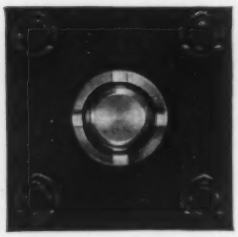
designed for leadership!

The superiority of Hannifin cylinders begins on the drawing board, where Hannifin designers have originated feature after feature not found in other air and hydraulic cylinders. But it doesn't end there...

Hannifin offers more kinds of cylinders, more sizes, more mounting styles. Each manufactured with such exacting control of dimensions and finishes that it not only looks like a better cylinder—its performance proves it!

As more and more discriminating specifiers and buyers are finding, the extra quality you get from Hannifin costs you no more, can usually be delivered sooner.

Why not specify Hannifin by name when you buy?



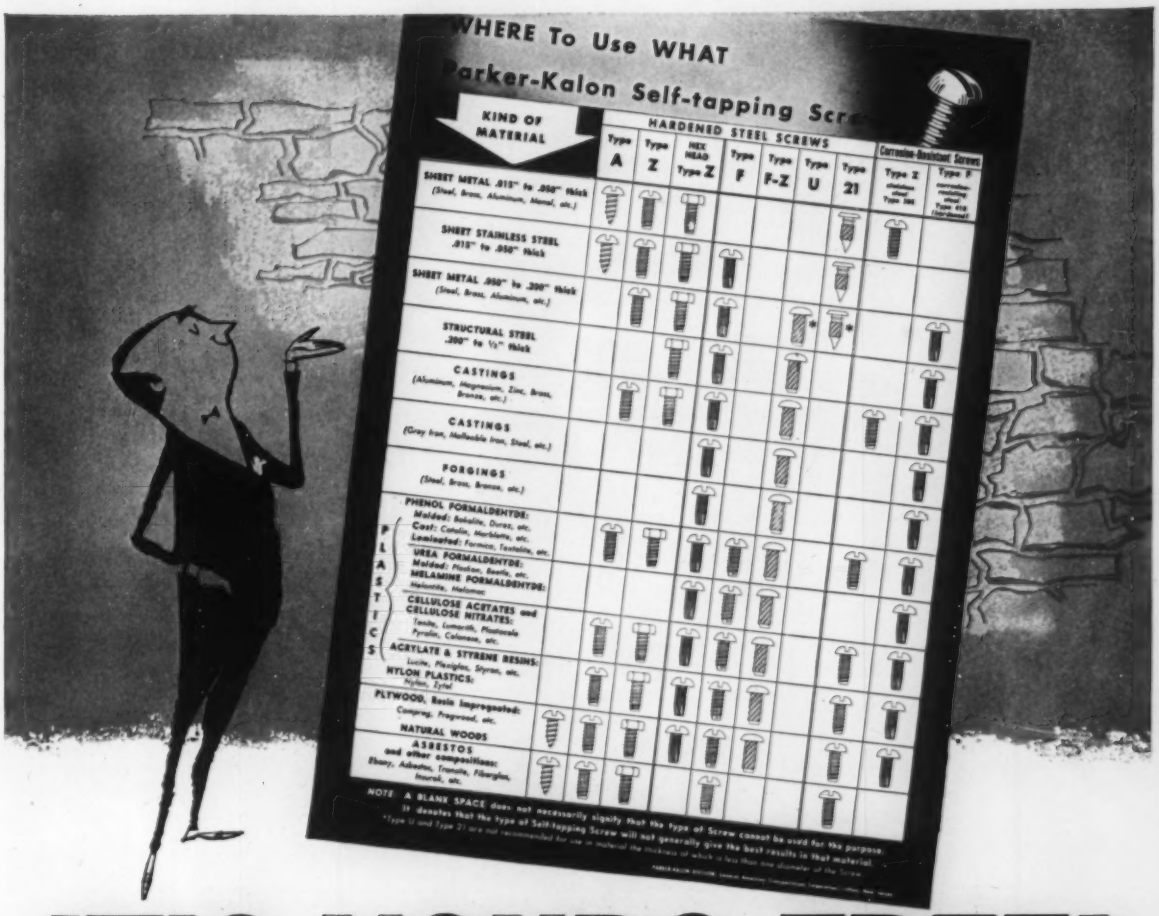
AIR AND HYDRAULIC

HANNIFIN

POWER CYLINDERS

Write for your copy of this new Hannifin Cylinder File—complete, easy-to-use, easy-to-order-from information on five lines of Hannifin cylinders. Hannifin Corporation, 515 South Wolf Road, Des Plaines, Illinois.

Circle 476 on page 19


WHERE To Use WHAT
Parker-Kalon Self-tapping Scr
KIND OF MATERIAL
HARDENED STEEL SCREWS
Type A
Type Z
HEX. HEAD Type Z
Type F
Type F-Z
Type U
Type 21
Corrosion-Resistant Screws
Type Z
Type F
SHEET METAL .015" to .050" thick
(Steel, Brass, Aluminum, Monel, etc.)
SHEET STAINLESS STEEL .015" to .050" thick
SHEET METAL .050" to .200" thick
(Steel, Brass, Aluminum, etc.)
STRUCTURAL STEEL .200" to ½" thick
CASTINGS
(Aluminum, Magnesium, Zinc, Brass, Bronze, etc.)
CASTINGS
(Gray Iron, Malleable Iron, Steel, etc.)
FORGINGS
(Steel, Brass, Bronze, etc.)
PLASTICS
PHENOL FORMALDEHYDE:
Molded: Bakelite, Durez, etc.
Cast: Catalin, Marblette, etc.
Laminated: Formica, Textolite, etc.
UREA FORMALDEHYDE:
Molded: Plaskon, Beetle, etc.
MELAMINE FORMALDEHYDE:
Melamine, Melmac
CELLULOSE ACETATES and CELLULOSE NITRATES:
Tenite, Lumarith, Plastacele
Pyralin, Colorcon, etc.
ACRYLATE & STYRENE RESINS:
Lucite, Plexiglas, Styron, etc.
NYLON PLASTICS:
Nylon, Zytel
PLYWOOD, Resin Impregnated:
Compreg, Pregwood, etc.
NATURAL WOODS
ASBESTOS and other compositions:
Ebony, Asbestos, Transite, Fiberglas, Neoprene, etc.
NOTE: A BLANK SPACE does not necessarily signify that the type of Screw cannot be used for the purpose. It denotes that the type of Self-tapping Screw will not generally give the best results in that material.
*Type U and Type 21 are not recommended for use in material the thickness of which is less than one diameter of the Screw.

IT'S YOURS FREE!

this see-at-a-glance Self-tapping Screw guide

Now . . . you can have this easy-to-read wall chart that instantly shows the proper type of self-tapping screw to use with various thicknesses of metal —with castings or forgings—with plastics—with plywoods, asbestos and other compositions.

Designers and engineers find this chart a handy, time-saving reference. Parker-Kalon, originators of the self-tapping screw, can provide the type you need in the size and head style you require.

For your own copy of this chart, 12½" x 16¾" printed in two colors, simply write to Parker-Kalon on your company letterhead.

PARKER-KALON®
fasteners

***PARKER-KALON DIVISION,** General American Transportation Corporation, Clifton, New Jersey. Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws. Sold everywhere through leading Industrial Supply Distributors.*

Circle 477 on page 19

How many hats do you wear?

IT HAS BEEN SAID that a product design engineer must wear many different hats. First of all, he has to think out a gadget that will do a certain job without falling apart. Then, he has to be a production expert because he has to be sure that his gadget can be *made*. Can it be made economically? He has to know some cost accounting. Has he specified screwball component parts? He has to know a lot about purchasing—what materials are available, when they can be delivered and all the rest.

Since most machines contain some springs, your design engineer should (ideally) also be a spring engineer. But don't you have to draw the line somewhere? The most skilled group of spring engineers in the nation are at your beck and call without any obligation. The men at American Steel & Wire have been specialists all their lives. A problem that is new to you may be old hat to them. More than that, they know spring-making *machinery*, and can suggest design modifications that will allow more efficient production methods. Result? Lower cost for you.

Like they say in the ads, no order is too small or too large. Just call your AS&W representative.

AMERICAN STEEL & WIRE DIVISION
UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO,
PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.,
SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN *QUALITY* SPRINGS

UNITED STATES STEEL

USS

Circle 478 on page 19

REX® GLIDE FIT

A new concept in Roller Chain Design

CONVENIENCE. New ease of coupling and uncoupling for multiple-width chains. Pins are a "glide fit" through inner link plates...a press fit only in the outer link plates.

LONG LIFE. You get the great convenience of Rex Glide Fit Roller Chains *plus* long life. Properly applied, there's no sacrifice of life or strength to gain the easy coupling.

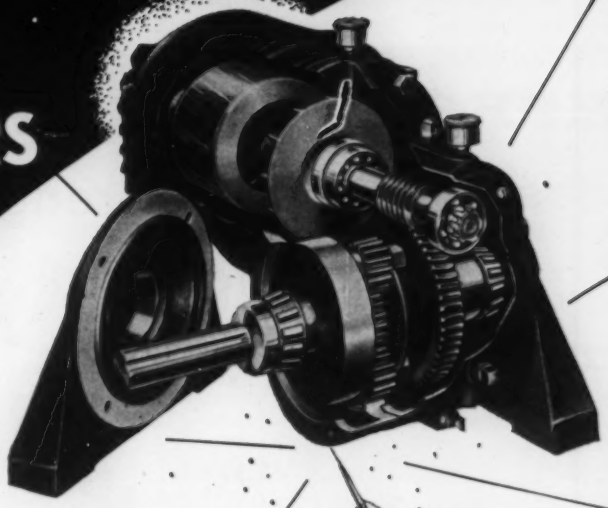
ECONOMY. The long life and easy coupling of Glide Fit Roller Chains mean lower operating costs...less nonproductive down time. You can couple these chains *faster*... uncouple them *faster!*

Get the complete story of all the advantages you get with Rex Glide Fit Roller Chains...the new concept in multiple-width chains. Write CHAIN Belt Company, 4643 West Greenfield Avenue, Milwaukee 1, Wisconsin.

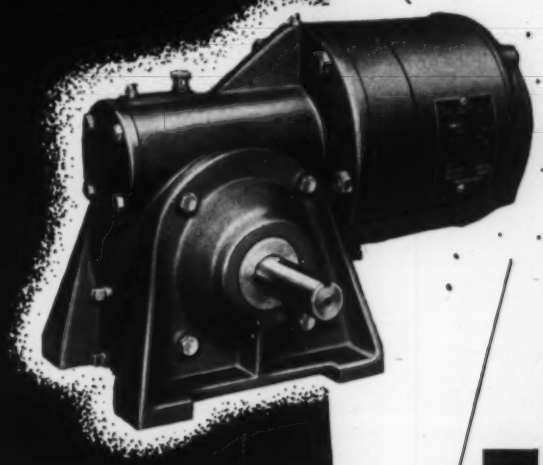
CHAIN BELT

Leadership...through creative engineering

FOR ENGINEERS TO EXPRESS THAT



One touch of genius . . .



THEY CHOOSE Janette

GEAR MOTORS • SPEED REDUCERS

Because engineers know they can depend on Janette to give the right speed at the right power in a wider variety of models with a larger choice of mounting positions, engineers make Janette their first choice.

Since 1910, Janette has been designing longer lasting, easier to maintain gear motors and speed reducers. Whether the requirements are for horsepower from 1/150 to 7½ or for one revolution every 5 hours to 450 R. P. M., Janette has the speed reducer and gear motor to do the job.

REPRESENTATIVES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES . . .

For additional information send for Janette bulletin 5-105, M2

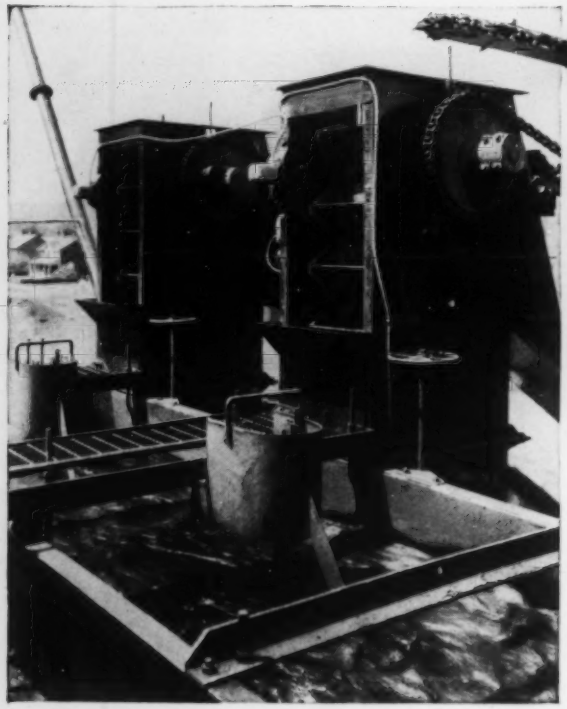
Janette ELECTRIC MANUFACTURING CO.
MORTON GROVE, ILLINOIS

Circle 480 on page 19

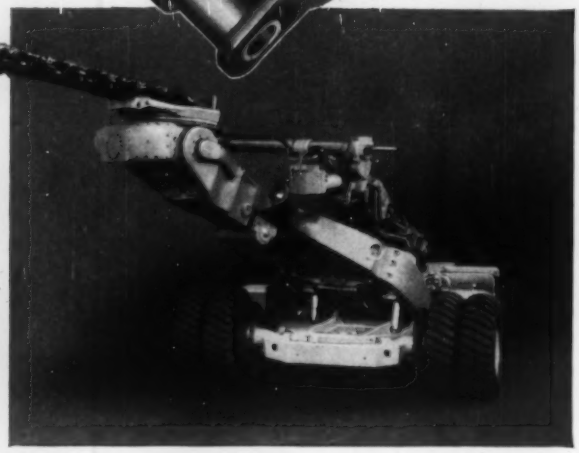
JEFFREY STR* CHAIN

has the reserve strength necessary for hard work and sudden overloads

*Steel Thimble Roller Chain



Jeffrey STR Chain on bucket elevator drive of cleaning jig.

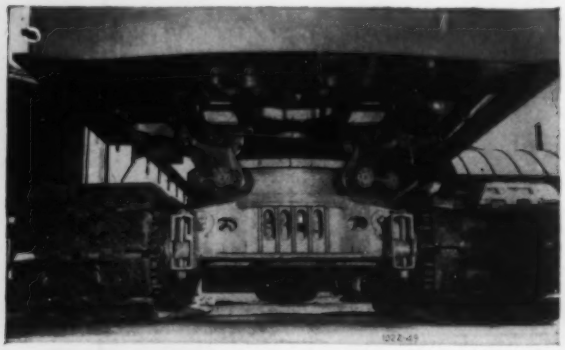


Jeffrey STR Chain on traction wheels of large cutter.

YOU SEE MORE and more Jeffrey STR Chain every day. Jeffrey's own high-quality equipment uses Jeffrey STR for dozens of power transmission and conveying applications. Other manufacturers incorporate Jeffrey STR as original equipment on machines they make. And operators everywhere replace chain drives of whatever make with Jeffrey STR.

With Jeffrey STR you get a balanced chain design with maximum strength and minimum weight. Moreover you get the reserve strength so necessary for the hard work and sudden overloads common under full-scale operations.

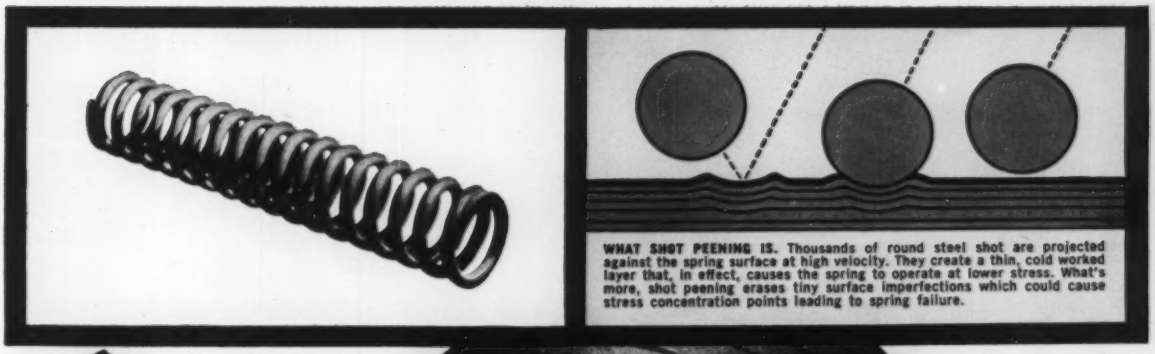
For dependable, long-life chain for power transmission, conveying and elevating service, see your nearby Jeffrey distributor or district office, or write to The Jeffrey Manufacturing Company, Columbus 16, Ohio.



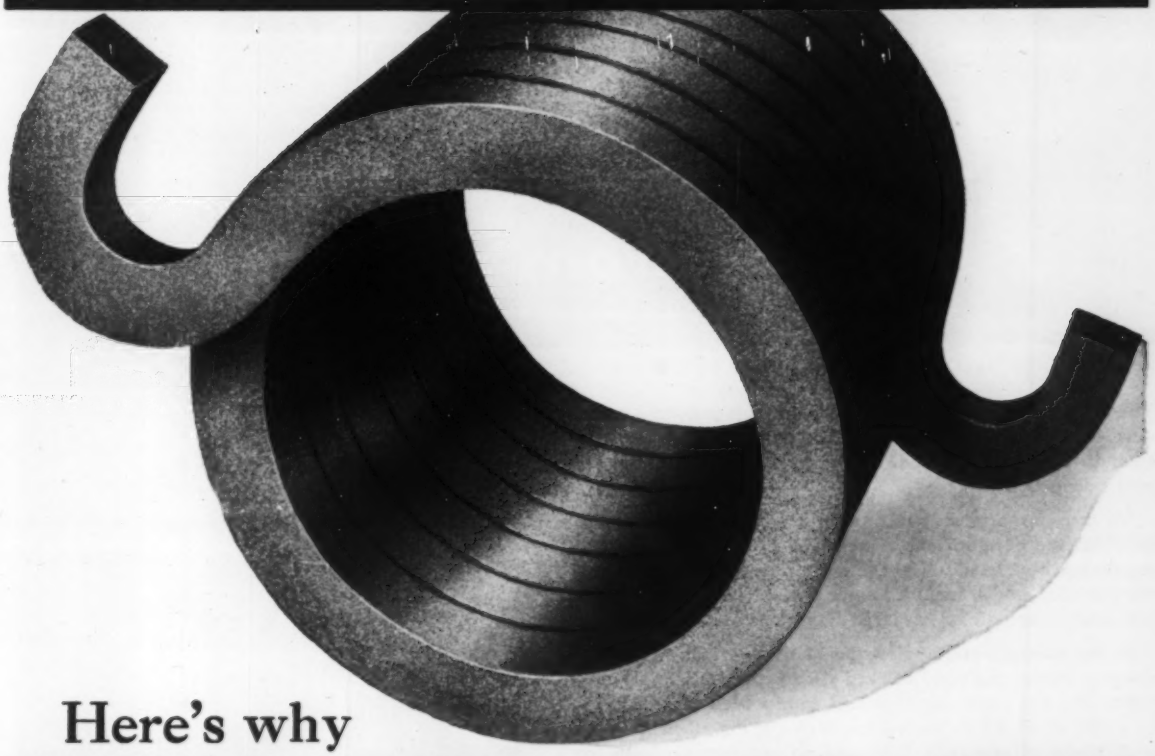
Jeffrey STR Chain on crawler drive of power shovel.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT • TRANSMISSION MACHINERY • CONTRACT MANUFACTURING



WHAT SHOT PEENING IS. Thousands of round steel shot are projected against the spring surface at high velocity. They create a thin, cold worked layer that, in effect, causes the spring to operate at lower stress. What's more, shot peening erases tiny surface imperfections which could cause stress concentration points leading to spring failure.



Here's why

CRUCIBLE FATIGUE RESISTANT SPRINGS

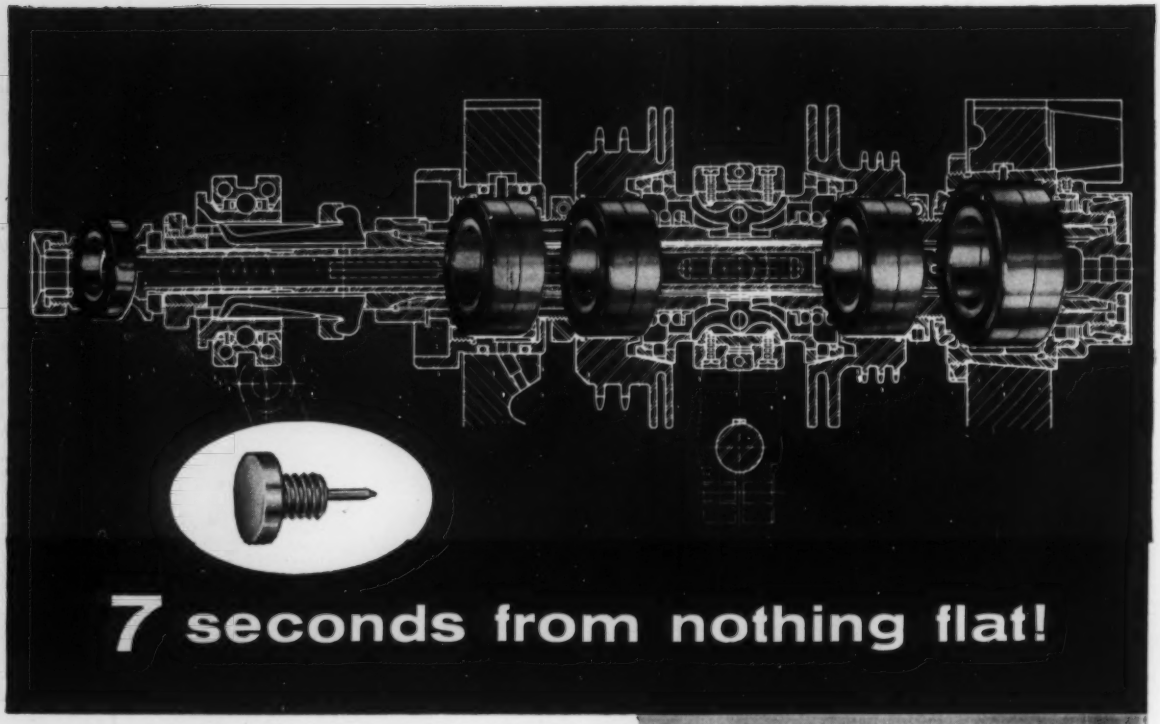
can withstand higher stresses

Every Crucible *fatigue resistant* spring for heavy-duty industrial applications is shot peened for higher strength and greater fatigue resistance. Crucible controlled shot peening imposes a negative stress on the surface that offsets positive stresses set up in service. Result: a truly *fatigue resistant* spring that outlasts conventional ones.

Good springs are a combination of proper design, skilled workmanship and fine steel. When you buy Crucible springs you employ a staff of proven designers and spring makers, and Crucible's years of experience in fine steel making—from ore to finished springs. Let an experienced Crucible spring specialist suggest the best *fatigue resistant* spring for your application. Or write for a copy of the "Handbook of Coil Spring Design." *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE spring division

Crucible Steel Company of America



7 seconds from nothing flat!

The brass part illustrated below the diagram is produced on the new 00 Brown & Sharpe Automatic Screw Machine in 7 seconds. That represents a 42% increase in production over the previous model.

To step up production by such a substantial percentage involved the development of new and exclusive features for the 00 machine over and above those proven so successful on the previous model. Included among them is the chain-driven, ball bearing spindle . . . see large diagram above.

In the selection and application of the bearings for the 00 spindle, Fafnir engineers worked with Brown & Sharpe engineers. The 208 speed combinations from a high of 7200 RPM to a low of 34 RPM, permitting high cutting efficiency on a wide range of materials, presented no ordinary problem for bearings. The bearing arrangement shown meets an exacting demand for maximum radial and axial rigidity to assure true balance and running accuracy of the spindle.

Could be there's no place in your machines for these super-precision bearings. But, whenever bearings are involved, there's certainly a place in your product planning for the Fafnir "attitude and aptitude" — a way of looking at bearing problems from the designer's viewpoint plus coming up with the right bearing to fit the need. Ask your Fafnir representative for details. The Fafnir Bearing Company, New Britain, Conn.

The New Brown & Sharpe No. 00 Automatic Screw Machine with Fafnir-equipped spindle.

Fafnir preloaded, angular-contact, super-precision ball bearings with composition or brass retainers are made to highest industry-approved tolerances. Single or duplex bearings like this are used widely on spindle applications.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

MACHINE DESIGN
June 13, 1957

Men or Boys?

TRADITIONAL concepts of development, design and quality control are inadequate to guide the creation of tomorrow's weapons. From the delivery vehicle—airplane or missile—to the warhead itself the requirement is for perfect, not just near-perfect, reliability and accuracy. The monstrous destructive power of nuclear explosives permits no alternative.

That fact alone would explain most of the current high demand for engineers. The whole weapons program is practically on a crash basis. "Clouds of engineers" are mobilized to overwhelm difficult problems by sheer numbers.

Thus it is probably true, as has been predicted, that a ten per cent cut in defense appropriations for research and development would disperse such clouds and eliminate the "shortage" of engineers.

But other factors may affect the picture for engineers. On top of the present research and development phases there will be growing emphasis on procurement and production of hardware. Engineering development responsibilities have been vested largely in a few prime contractors, mostly airframe manufacturers. Their resources and management know-how have been needed to integrate the skills and capabilities of specialized industries into complex weapons systems.

So it has appeared to some that a "munitions" industry composed of these groups was being fostered by the current defense program. It is reassuring to know, as Major General David H. Baker reminded the Society of Business Magazine Editors last month, that the Air Force has no such intention. Manufacturers of major accessories, subsystems and equipment will participate on a prime contract basis. This means that firms specializing in electronics, hydraulics and other major component systems will deal directly with the Government on procurement and production, rather than through another prime contractor.

Because of changing concepts, with quality in weapons supplanting quantity, production volumes will not be high, but dollar value will be. There will be keen competition for the relatively few contracts, and engineers inevitably will find themselves involved in job shifts—not an easy step for some. The complexity of systems and the advanced engineering needed will demand concentrated engineering competence, rather than clouds of sometimes mediocre effort. It is a situation that will surely separate the men from the boys.

Colin Carmichael

EDITOR

Planning Product Strategy

Philip R. Marvin
Manager, Research and Development Div.
American Management Association
New York

Companies must grow. Effective growth means new products. Profitable new products require planning. Successful planning is built upon a knowledge of underlying economic bases and skill in integrating many diverse factors. This article considers the overall aspects of product planning; following articles in this engineering-management program will explore five essential phases:

- **Finding New-Product Ideas**
- **Screening and Appraising Ideas**
- **Testing and Evaluating Proposals**
- **Commercial Development of Products**
- **Preplanning for Production**

INDUSTRY position can not be maintained by steady adherence to today's policies and programs. The growth dynamics of the industrial economy make this impossible. Mere maintenance of present position calls for long-range planning. Lack of planning and growth reveals stagnation, in proper perspective, as a relative decline.

Annual reports emphasize that over 80 per cent of the sales volume in a number of growing corporations results from products that were unknown ten years ago. These patterns are characteristic of vigorous businesses ranging in size from relatively small corporations to industrial giants. Active corporations are vitally concerned with growth: growth of volume, earnings, and increased stability of operations. This growth is inseparably linked to the development of new products. The importance that must be attached to long-range planning can be readily recognized.

Planning product strategy calls for dynamic, imaginative thinking—an approach that is often quite unfamiliar to those executives who rose through the ranks primarily because of their ability to execute established procedures with precision. The greatest stumbling block is usually encountered right at the start: maneuvering into position to attack the problem. This is understandable because the attack is being planned against the unknown—the future.

As is often true, the way becomes easier when a program for action is laid out. Planning product strategy represents no exception. Adherence to a specific plan permits the problem to be attacked systematically.

Determining Present Position

An analysis of growth patterns forms the starting point for long-range planning by revealing the vitality reflected by individual industry groups. There are certain specific tools which can be used in implementing a program. One of the most useful is the Federal Reserve Board's *Index of Industrial Production*. This index reveals changes in the physical volume of output in the manufacturing and mining industries. It is particularly useful inasmuch as 130 monthly series are published indicating activity in a wide range of separate and distinct industries. For most cases, this information permits a general comparison of the activity in an individual business with its associated industry.

A composite figure combining indices of activity in the various industries is also published monthly and annually providing an over-all measure of business activity. In developing an approach to planning product strategy, and more specifically, in studying growth trends, this combined index reveals significant information. In 1947 the annual rate of industrial activity based on the index was 100. Ten years later, at the end of 1956, the average annual rate of industrial activity had increased over 40 per cent. This increase in the physical volume of output in the preceding ten-year period is one indication of the industrial growth rate.

Another indication of growth is reflected in the increase in the Gross National Product, the market value of the nation's output of goods and

for long-range growth and profit

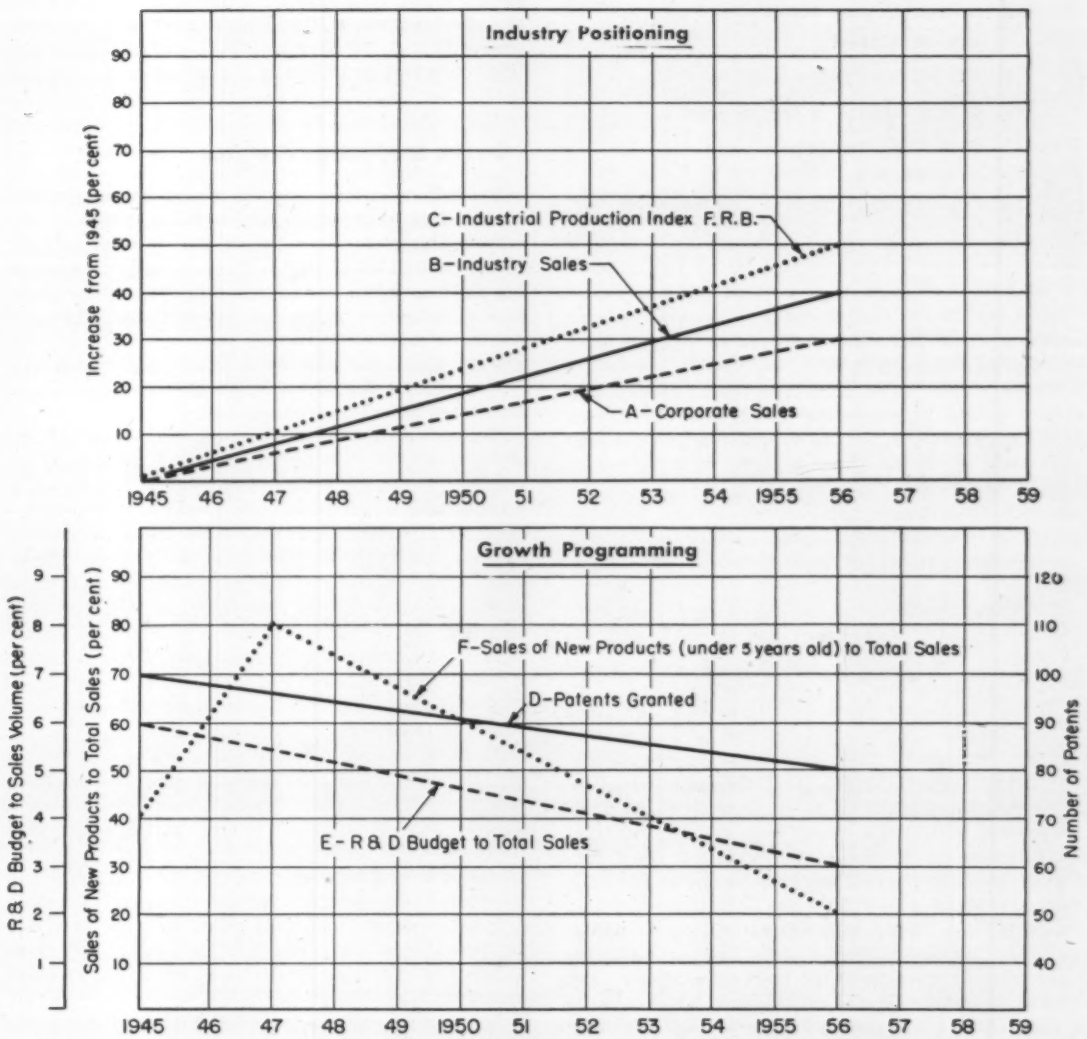

Industry Positioning
Increase from 1945 (per cent)
C–Industrial Production Index F.R.B.
B–Industry Sales
A–Corporate Sales
Growth Programming
R & D Budget to Sales Volume (per cent)
Sales of New Products to Total Sales (per cent)
Number of Patents
F–Sales of New Products (under 5 years old) to Total Sales
D–Patents Granted
E–R & D Budget to Total Sales
1945 46 47 48 49 1950 51 52 53 54 1955 56 57 58 59

Fig. 1—Business-analysis chart for measuring past performance, evaluating present position, and projecting future plans. This chart indicates a corporation that is slowly losing position, even in its slow-growth field. Lower half of chart pinpoints lack of new-product development in recent years.

The New Product

New function, added function, and cost-reduction features embodied in new products result in substantial returns to the corporation:

1. **Growth is made possible**
2. **Seasonal effects can be levelled**
3. **A hedge is provided against recession**
4. **Impact of business cycles is reduced**
5. **Risks are spread over a wider base**
6. **Work loads can be better-balanced**
7. **Management perspective is broadened**
8. **Technical and managerial talents are developed**
9. **Tax advantages accrue**
10. **Excess capital is put to work**
11. **Product-line obsolescence is avoided**
12. **Product opportunities are realized**

services, from 232 billion dollars in 1947 to over 400 billion dollars in 1956.

These indicators of industry growth provide reference points in projecting plans into the future. It is not feasible to outline a series of comparisons that will be useful in every type of business. It should be possible, however, to select suitable indicators to measure the activity in any business to reveal whether it has been leading or lagging the general pattern of related industry performance.

To bring together on one chart significant data for purposes of analyzing past growth and for projecting future plans, the 20-year development analysis, Fig. 1, will be found valuable.

The chart shown gives data that were developed in the course of an analysis of the growth pattern for one corporation. The specific data used initially has been smoothed out to facilitate analysis. Line *B* shows the growth of sales from 1945 to 1956. Compared with 1945, operations in 1956 reflected an increase of 30 per cent. Taken by itself this figure does not provide an adequate basis for long-range planning. However, when it is recognized that industry sales in the aggregate for this particular industry increased 40 per cent, line *A*, while the industrial production index increased 50 per cent, line *C*, a perspective is established which creates a firm basis for planning future product strategy.

Three other useful curves are presented on this same chart for analyzing past performance as a basis for future planning. Line *D* indicates that the number of patents granted to the corporation declined steadily over the period shown. The ratio of the corporation's research and development budget to the sales volume, line *E*, also declined steadily over this same period. The consequence of executive action reflected by lines *D* and *E* is shown in line *F*. This indicates a steady decrease in the ratio of sales volume of new products, those less than five years old, to total sales.

In this particular case, not only is the corporation seriously lagging behind the general growth pattern, but it is also failing to revitalize its product line. There is a strong possibility that the fall-off in the introduction of new products since 1947, as reflected in line *F*, may have catastrophic effect on business operations.

A chart of this nature permits establishing the present competitive position of a corporation and helps provide perspective for future planning. It assists those responsible for planning by indicating the effectiveness of the decisions made in the past and indicates whether or not a radical departure from previous practices is necessary or justifiable.

▶ The Long-Range Program

Product planning must be based on recognition of the fact that expanding business horizons are setting the pace. New opportunities are constantly being created as a result of the steadily increasing population, shifts in age grouping within the population, increased industrial productivity, shifts of available disposable income within various income groups, and other aspects of our dynamic economy.

Four major factors must be given special attention when planning product strategy:

Technological development has advanced rapidly as a result of both industrial and governmental research expenditures in recent years. Nearly eight billion dollars were spent for research and development in the sciences during 1956. Industry's share of this total ran slightly over five billion dollars. The tenth edition of the *Directory of Industrial Research Laboratories*, published by the National Academy of Sciences, National Research Council, lists 4834 industrial research laboratories operated by 4060 corporations. Thirty-five years ago, when this directory was first published, 290 industrial research laboratories were reported.

Looking ahead, industry will spend an estimated six billion dollars on research and development during the year 1957. Research and development in the federal budget for the fiscal year 1958 amounts to 3.4 billion dollars.

An accelerating stream of new products and processes will inevitably result from such expenditures. Products and processes will be available to those who have had the foresight and have taken the initiative to direct funds into favorable channels.

Functional engineering reflects the growing importance of the relationship of the consumer to the product. Corporations undertake research not only to keep up with advancing technology but to develop knowledge of changing consumer require-

ments. Vital consumer data must be constantly fed to the research group for analysis and action. Today's products are incorporating increasing increments of design requirements dictated by the needs, whims and fancies of customers.

Patent development is a third factor to consider. Regardless of controversial fringe aspects of patent development, patents protect research and development expenditures by providing a monopoly for a period of time as an incentive for the expenditure of these funds. Those who plan ahead enjoy these rewards.

Legislative enactments are a fourth factor. The enactment of laws and their interpretation by the courts both open and close doors on business opportunities. This is a continuing process with the picture constantly changing. Product strategy should capitalize upon these developments and trends.

To combat and capitalize upon these factors at the same time, an aggressive planned program is required. New products are needed. New products are those that supply new function, added function, or lower cost. Features contributing to cost reduction fall in the new product category because, as a consequence of lowered costs, products become available to those who otherwise could not afford them. To this potential group of customers, these products *are* new products.

▶ From Idea to Production

Product strategy unfolds in a sequence of five steps starting with the generation of ideas and ending when production and distribution commence. The initial stage is devoted to the development of new ideas. One of the ingredients of success in developing new product ideas lies in the isolation of this stage from other stages in the development process. Every effort should be made to accumulate as many new ideas as possible. Quantity, not quality, should be emphasized at this point. An important aspect of placing emphasis on quantity is to avoid premature rejection of ideas before selection criteria are well established and to avoid rejection of ideas by individuals whose talent lies in the direction of developing ideas rather than evaluating them.

Finding product opportunities—the need for new products—is equally as important as new-product ideas themselves at this point. The need for a product often is a very valuable stimulant to a flow of ideas.

The search for ideas should be pursued vigorously at every possible source, both within the corporation and on the outside.

The second stage in the development process represents screening the ideas. Every idea is reviewed and appraised on the basis of the best obtainable data, however meager it may actually be. In a final screening process, the best ideas are selected for further development. Relative evaluations must be made but it is seldom possible to deal in absolutes. The course of action chosen must represent the best that is available.

In the third stage, ideas that have passed the final screening are developed into breadboard mod-

Evaluating Resources for Business Development

A critical evaluation of a firm's resources is essential to sound planning. This check list should reveal any consequential deficiencies.

1. **Is background of executive experience going beyond the existing product line available?**
2. **What is the availability of excess funds, funds beyond those required for current operating needs?**
3. **Are fiscal policies sufficiently flexible?**
4. **Would stockholder reaction be favorable to new ventures?**
5. **What latitude is provided in the corporate charter for new undertakings?**
6. **Can the corporate structure be adapted to new ventures?**
7. **How would the directors respond to new programs?**
8. **Would the present product line be excessively sensitive to new programs?**
9. **What is the character of the market structure?**
10. **How would present distribution channels fit new programs?**
11. **Does the sales organization show vitality?**
12. **How adaptable are production facilities?**
13. **Are production facilities competitive from the standpoint of efficiency?**
14. **Does depth of talent exist in the engineering group?**
15. **Are management objectives in conflict with development objectives?**
16. **How well developed are the programming methods?**
17. **Are present policies flexible?**

els. The idea begins to take shape and form and the actual feasibility of the idea itself is tested. Up to this point most of the ideas merely represented a thought expressed on paper. In this stage a combination of research, engineering and technical-economic study puts the practical utility of the idea to test. The end product of this stage is a working model.

In the fourth stage the product undergoes commercial development. Starting as a working model, the idea is engineered into form as a production prototype. This prototype is soundly engineered for both performance and production. Engineered to meet the needs of the customer, in every respect this prototype should resemble the product that may ultimately come off the final-assembly line.

The final stage of new product development is devoted to planning for profitable production. In this stage final decisions are reached concerning which elements will be produced and which will be purchased. Pilot runs are undertaken to develop production methods. A distribution organization is activated so that it will be ready to perform at the same time the product is released to the market.

▶ Evaluating the New Product

Success hinges on the ability to correlate alternatives from the standpoint of potential return, estimated costs and relative timing. In accomplishing this, each potential new product should be subjected to a penetrating analysis in nine significant areas:

1. What are the important features of the proposed product? Selection calls for a complete understanding of each product proposal.
2. How do patents and licenses affect introduc-

Research and Engineering Roles in Product Development

In many corporations the research and engineering organizations perform unnecessarily overlapping activities. The result, in most cases, has been not a multiplication of effectiveness of the two but rather a cancellation of effectiveness.

The scientist's function in the research organization is the detection, classification and organization of facts, laws and hypotheses relating to phenomena, materials and the arts. The engineer's function is to translate these facts, laws and hypotheses into commercially feasible new or improved products for sale. In other words, the engineer's job is to turn ideas into products. Understanding and knowledge of natural phenomena, materials and industrial arts are required. The engineer is charged with the responsibility (although not the sole responsibility) for the commercial development of product ideas. Products must be designed that can be produced economically and that will perform satisfactorily. Satisfactory performance means not only that the product will do the job expected by the customer, but that the design takes into consideration problems such as distribution, installation, adequate service and maintenance.

The basis of the knowledge which the engineer applies often comes from earlier research efforts. Such research may be classified into six categories, depending upon its primary purpose:

1. **Fundamental Research—new knowledge without reference to specific end use.**
2. **Applied Research—directly applicable to solving a specific problem relating to the product, its application, production processes, or production equipment.**
3. **Product Research—improvement of existing products or adaptation to special or new applications and uses.**
4. **Application Advisory Research—aiding customers in application of company products.**
5. **Production Process Research—improving methods of production for certain types of products.**
6. **Production Equipment Research—providing improved equipment and facilities for manufacturing purposes.**

The function of research is to develop understanding and knowledge. In the long-range corporation picture, there are six goals or objectives to be achieved by developing new knowledge:

1. **To insure that the corporation will continue to to operate in areas of growing business activity.**
2. **To make best possible use of corporation resources such as raw materials, technical specialties and management talent.**
3. **To utilize available markets adequately.**
4. **To diversify corporation activities.**
5. **To insure steadily increasing and stable profits.**
6. **To contribute to the corporation's ability to accept social and humanitarian responsibilities.**

Part of the misunderstanding between research and engineering rolls results from the fact that the responsibilities of the two change during the development of a project. If one idea-project were followed from first discovery to final effective incorporation in a product, it would be noticed that in the beginning, the idea was entirely within the sphere of research. As

tion of the product? A thorough review should be made of patent and licensing relationships. Adequate patent protection is essential to cover development costs and to return the investment.

3. What is the market for the product? One of the vital steps is appraisal of such factors as customer characteristics, geographic peculiarities of the market, and list price necessary to secure volume. Other aspects are market development, life of product, life of market, saturation, estimated sales, and time of introduction to market.

4. What is the outlook for the market identified with the proposed product? Final consideration of a new product should be based on a comprehensive survey of the future potentialities of the market.

5. How much threat does technological development present? At the same time that research offers a source of new products, it also holds out a constant threat that these new products will be obsoleted by further research before development work can be completed and the products introduced. The chance of early obsolescence from subsequent developments must be carefully evaluated. A product's life span can be shortened by rapidly advancing technology to the point where it is impossible to recover the investment. This threat from research proceeds in two directions: A product may become unsaleable as a result of advanced design, and market shifts may result from new developments in relatively unrelated fields of technology.

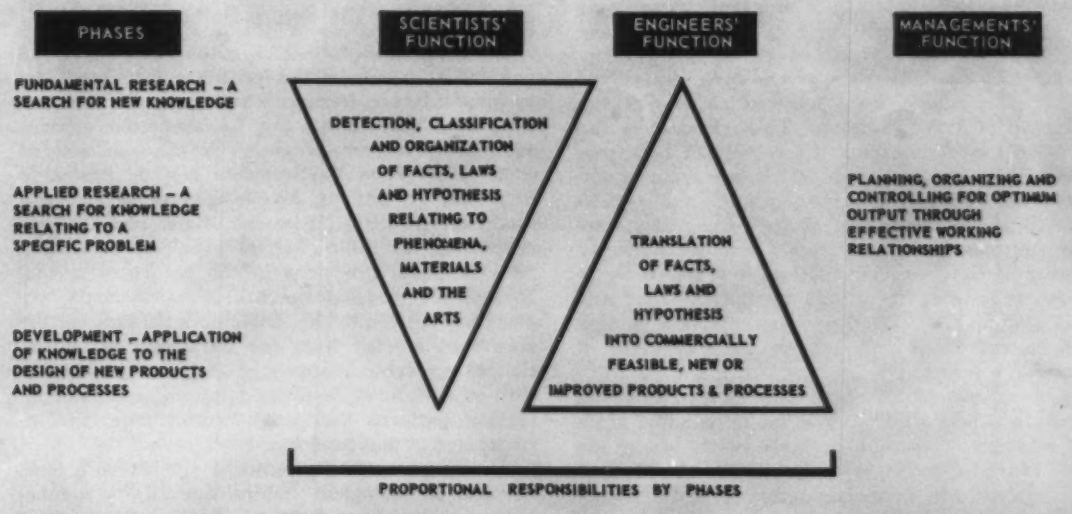
6. What effect will a proposed product have on relationships with other products offered? New products generally necessitate adjustment in established product lines. This adjustment may ex-

research activity defines the idea and determines its nature, engineering becomes interested in possible uses for it. Later, research will have begun to explore related avenues that may have opened. Engineering is in the process of evaluating this new information in its relationship to existing or new products. By the time engineering has accepted full responsibility for applying the idea, research has measured and classified it and gone on to new ones that repeat this cycle of idea development.

This concept is an obvious oversimplification, but demonstrates the shift of responsibility involved in development work. The function of management during this cycle is to plan and control this progressive shift of responsibility so that it is executed smoothly and that the complementary roles of research and engineering work together for the best overall interests of the corporation.

INDUSTRIAL RESEARCH AND DEVELOPMENT

FUNCTIONAL RELATIONSHIPS


PHASES
SCIENTISTS' FUNCTION
ENGINEERS' FUNCTION
MANAGEMENTS' FUNCTION
FUNDAMENTAL RESEARCH – A SEARCH FOR NEW KNOWLEDGE
APPLIED RESEARCH – A SEARCH FOR KNOWLEDGE RELATING TO A SPECIFIC PROBLEM
DEVELOPMENT – APPLICATION OF KNOWLEDGE TO THE DESIGN OF NEW PRODUCTS AND PROCESSES
DETECTION, CLASSIFICATION AND ORGANIZATION OF FACTS, LAWS AND HYPOTHESIS RELATING TO PHENOMENA, MATERIALS AND THE ARTS
TRANSLATION OF FACTS, LAWS AND HYPOTHESIS INTO COMMERCIALLY FEASIBLE, NEW OR IMPROVED PRODUCTS & PROCESSES
PLANNING, ORGANIZING AND CONTROLLING FOR OPTIMUM OUTPUT THROUGH EFFECTIVE WORKING RELATIONSHIPS
PROPORTIONAL RESPONSIBILITIES BY PHASES

tend to relationships with other manufacturers, changes in the scope of the market for existing products, operating policies, specific management or stockholders' interests, and related factors. The effect of new-product proposals on all corporate relationships must be evaluated and favorability of the net effect determined.

7. What competition can be anticipated? Competition plays a major part in determining a product's success or failure. Who are the competitors? How significant are they in the industry? What are their practices? Not the least important is the question concerning the time period required to get on the market with a competitive product. An assessment of strength and stability must be made for each corporation that represents a competitive threat.

8. What are the estimated costs and potential profits? Adequate basic data forms the only basis for cost estimates and projections of potential profits.

9. How should the product be distributed? Distribution must be surveyed to establish the probable degree of success in economically reaching the point of sale. Products can not be sold unless customers can be reached economically and effectively. To a very large degree the distribution may determine the success or failure of a new-product offering.

These nine questions probe specific areas of the product picture that are important in making any systematic analysis for the purpose of picking profitable products. Sound product decisions cannot be made without the answers to these questions.

Evaluating Resources

In developing new products it is necessary to know exactly what there is to work with. A critical, comprehensive evaluation of resources is essential in successfully shaping up a program. An analysis of the manpower area is first and should take into consideration a wide range of factors. The background and interests of the directors of the corporation should be considered as one of the elements of this evaluation. These men have the last word in determining the destiny of both proposed programs and those which are actually undertaken. The interests, background and experience of management men at both the policy level and the operating level should also be subjected to careful analysis. Still further, it is necessary to know the availability of the specialized talent and skill required to put new programs into motion and to carry out and achieve the objectives of current programs.

A clear concept of fiscal policies and financial strength is also vitally important in planning product strategy. The total of funds available and the cost of these funds must be known. Funds will be required for financing research and development, building new plants and for investment in equipment and inventory as well as the establishment of adequate working capital to carry these programs forward.

Not only is it important to know what physical facilities are available, such as manufacturing plants, warehouses and offices, and the specific equipment available at each of these points, but it is also important to know the relative efficiency and flexibility of these facilities.

Location factors should be considered separately. New programs generally mean new markets, new raw materials and new demands by way of special utilities.

Distribution programs should be carefully scrutinized. Present market areas, methods of penetrating these market areas, and sales vigor should be studied from the standpoint of effective utilization and flexibility. The flexibility will largely determine the degree that present distribution facilities can be used in new programs.

Ownership or preferential access to natural resources, minerals, ores, natural gas, and the like, is often cited as an important factor in planning new programs and, where applicable, should be given serious consideration.

Research and engineering facilities as well as the training and experience of scientists and engineers in these programs should be carefully appraised. Special capacities here are often the basis for product programs.

Any evaluation of resources should give careful attention to an analysis of patent ownership. Not only should product strategy be designed to develop available patents to the fullest extent but at the same time it should be designed to do this in a manner which will not create legal problems.

Present products and their acceptance by the market should be considered. Future strategy should be designed to strengthen and broaden the base of customer acceptance of products and the brand name associated with these products.

Evaluating the Future Potential

Based on the information gathered it should be possible to evaluate the probable future of the programs under consideration. Research and development investment can be evaluated against available resources, potential profits, and related costs. Production requirements can be evaluated in a similar manner. Maximum use of available facilities, personnel, raw materials, and utilities is usually desirable. Special problems associated with proposed programs in the nature of special hazards or unusual operating requirements are particularly significant. Distribution requirements should be studied from the standpoint of utilization of available channels of distribution, the nature of additional facilities required, and the conflicting patterns that might result from the introduction of new products.

Growth potential is measured against both market and technological factors. Stability is a function of a number of factors including opportunities for a captive market, the time involved in intro-

ducing a competitive product, the sensitivity of the product to business cycles and political developments, breadth of the market and long-range potential.

Measuring the probable return on proposed projects is probably the most difficult task of all. A commonly employed appraisal ratio is calculated by taking the estimated value to the firm of a successfully completed program, multiplying it by the probable chance of achieving success and dividing the resulting figure by the estimated cost of the program.

This isn't as easy as it looks on the surface, however. Economic, scientific, and technological considerations enter into this appraisal ratio. Each element is based upon judgment rather than factual data. While the appraisal ratio brings together in an orderly manner data pertinent to evaluation, the probable error in each of the factors entering into this appraisal ratio is carried over into the final result. To the degree that it is possible to correctly evaluate the factors entering into the appraisal ratio, it is an aid in selecting programs.

Probably the soundest basis for evaluating programs is that provided by comparing the value of future income from the program with the expenditures needed to finance the program. In this way, programs and the associated investment can be evaluated on a single scale. In using this method of evaluation, predicted annual profits are discounted backward to find their current present worth or their value at the time the investment would be made.

In discounting these figures backward, varying rates of interest are used in order to find the interest rate that causes the discounted value of future profits to be exactly equal to the amount of money to be currently invested in the project that would yield this return. To do this requires estimates of the total investment, including a time schedule for these investments, projected annual return by years and time schedule accompanying it, the useful life of the equipment, the probable depreciation allowance and the expected income-tax rates on profits.

▶ Timing the Program

Goals alone are relatively meaningless. Unless these goals are shown on a time-table basis the future is left vague. In particular, timetables should be established with respect to the following factors:

1. Research and engineering
2. Resource development
3. Commercial development
4. Plant and equipment development
5. Staff development
6. Return of capital investment

While certain of these time periods will run consecutively, each is important in establishing the timing for the proposed program.

▶ Establishing Sources

In the course of planning product strategy, decisions must be made concerning sources. Ideas may be developed or purchased. Engineering may be purchased on the outside. In a broader sphere, a product or a company may be purchased.

Source decisions should reflect both breadth and depth of thinking. Recognizing that components, corporations, patents and personnel may be involved, a true perspective of the wide range of problems involved is established.

There are many ways of approaching these decisions. All of them ultimately should take cognizance of the fact that time, money, resources such as raw materials, ideas, patents and technical talent are all being paid for, even if not purchased outside.

The course of new-product planning finds few corporations with both the time and funds needed in developing new products, processes and necessary production facilities. Ideas alone are difficult to develop. Outright purchase may be the only course open.

Some treat each acquisition as a unique problem. This should not be done. Every purchase made by the corporation is an acquisition, varying only in scale. Fundamentally the same factors which come into play in analyzing a new-product proposal are applicable to all acquisitions. If this is kept in mind, purchases and acquisitions at every level can be approached in a rational manner. This further emphasizes the importance of developing a clear understanding of the concepts underlying the process of planning product strategy.

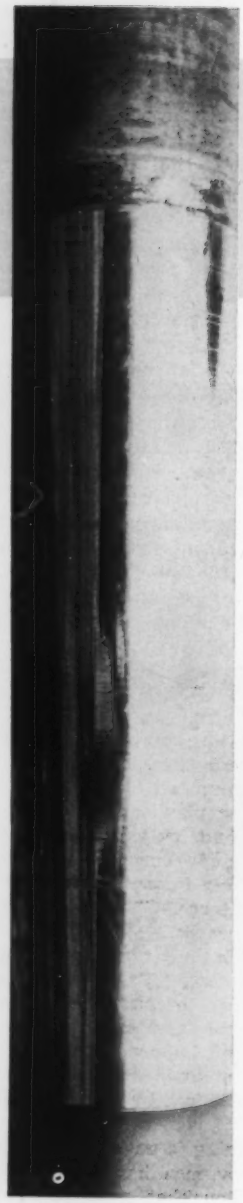
▶ The Challenge and The Opportunity

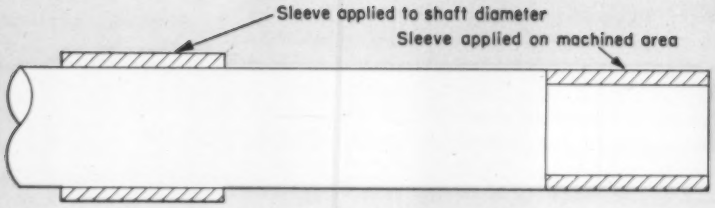
Planning product strategy is undoubtedly the most taxing and harassing problem confronting a company. At the same time it is one of the most challenging opportunities. The horizons are relatively unlimited. The planners must take all of the available facts and, anticipating probable patterns of industrial and consumer activity in years ahead, set programs in motion designed to fit into these new patterns. Those who accept the challenge reap the rewards.

Some argue that such long-range planning is purely a gamble. They say, "it's better to wait and see." Unquestionably, events of the future can be forecast with the greatest accuracy by simply waiting until they happen. Losses due to forecasting errors will undoubtedly be minimized but they are more than offset by losses resulting from unrealized business opportunities.

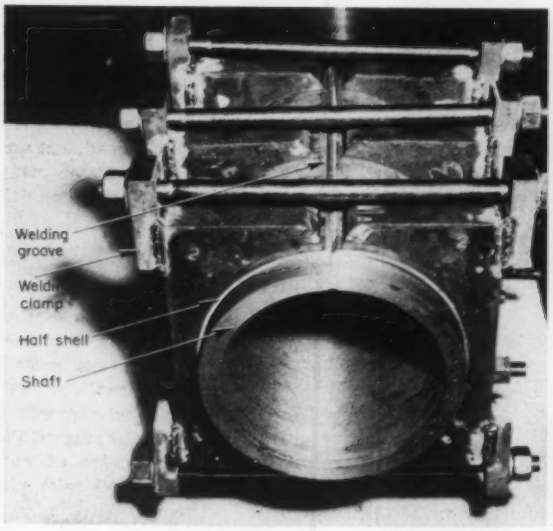
Product-strategy planning is an assignment that should be undertaken by men having vision and the courage of conviction that predicted future events will take place. On such forecasts the future is built.

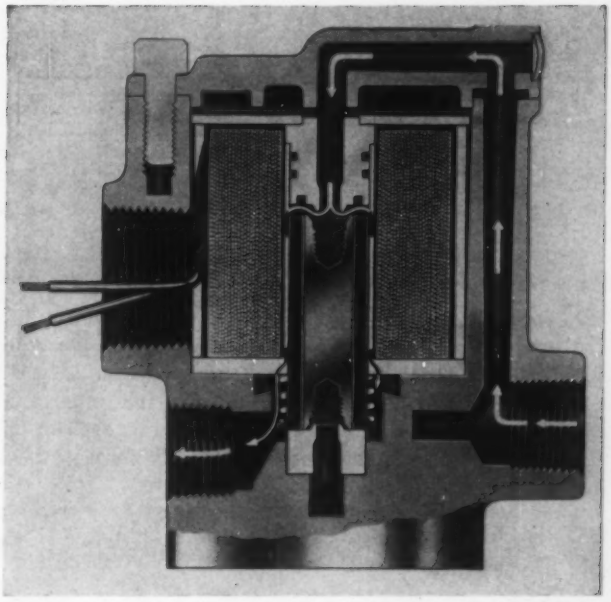
scanning the field for *ideas*



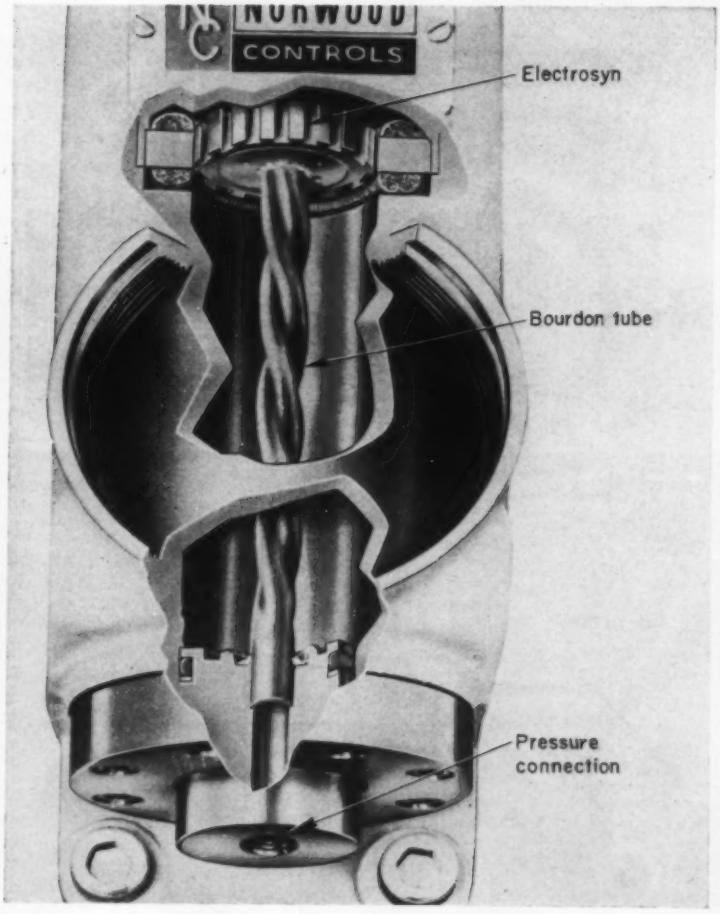


Wear-resistant bearing surfaces for rotating shafts are provided by hard cobalt-base alloy sleeves. Developed by Haynes-Stellite, the half sleeves are welded to the shaft at the bearing locations, either directly on the surface of the shaft or on machined, recessed areas. The sleeves are tightly clamped during welding. This, plus subsequent shrinkage of the welds, insures a tight surface contact between sleeve halves and the shaft. After welding, the sleeves are machined or ground to the final diameter.

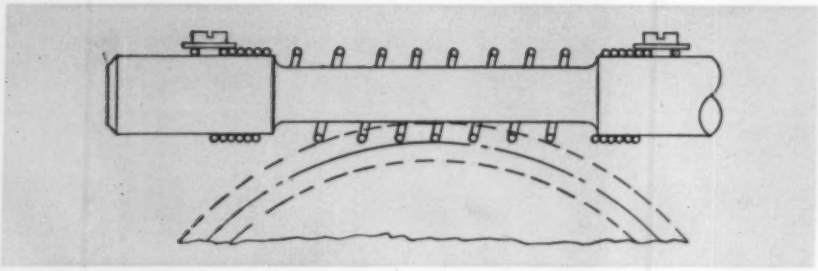




Internal fluid cooling of solenoid coil maintains low operating temperature and prolongs life of the unit. Fluid passing through the Valvair Speed-King solenoid valve circulates through the center of the actuating coil, between the tube and the plunger, effecting cooling of the coil and lubricating and cleaning the plunger. The coil is epoxy-resin encased for insulation and protection and is sealed off from the fluid by multiple seals.



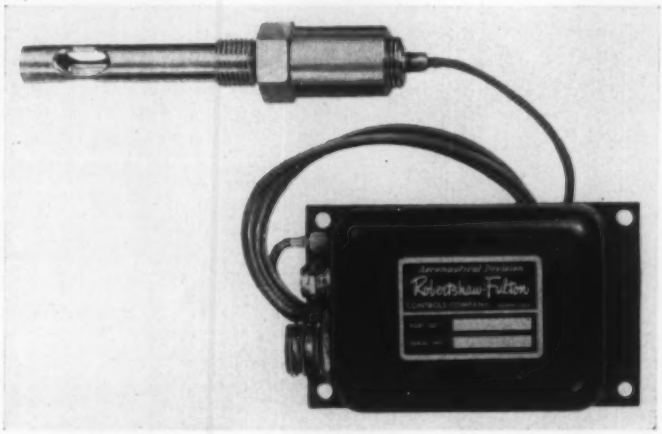
Twisted "Bourdon" tube converts pressure variation directly into voltage change, without mechanical linkages, in a novel pressure transducer. Developed by Norwood Controls, the twisted tube is fixed at the inlet end. Pressure variation within the tube results in shaft rotation of an Electrosyn that is mounted on the closed, free end of the tube. Change in output voltage of the Electrosyn rotary-differential transmitter is proportional to the pressure variation.

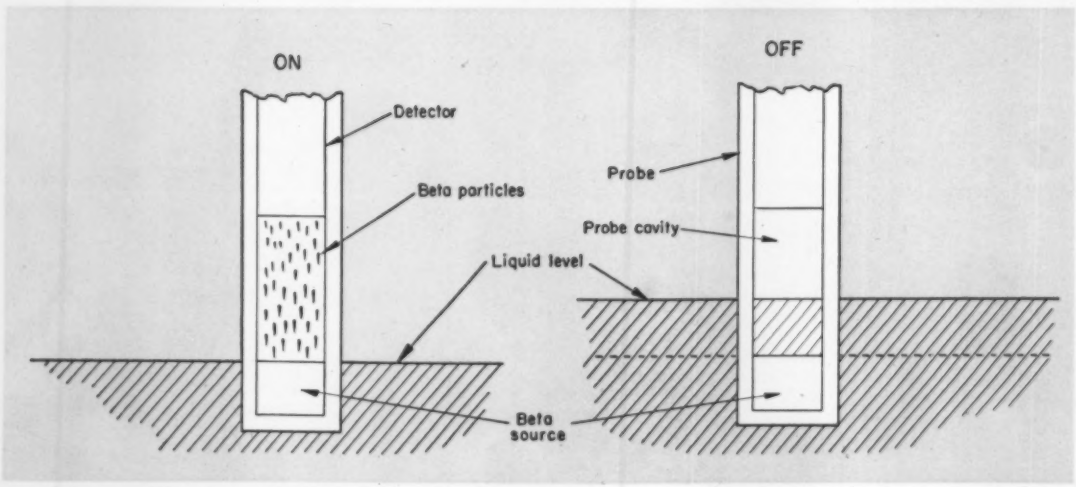


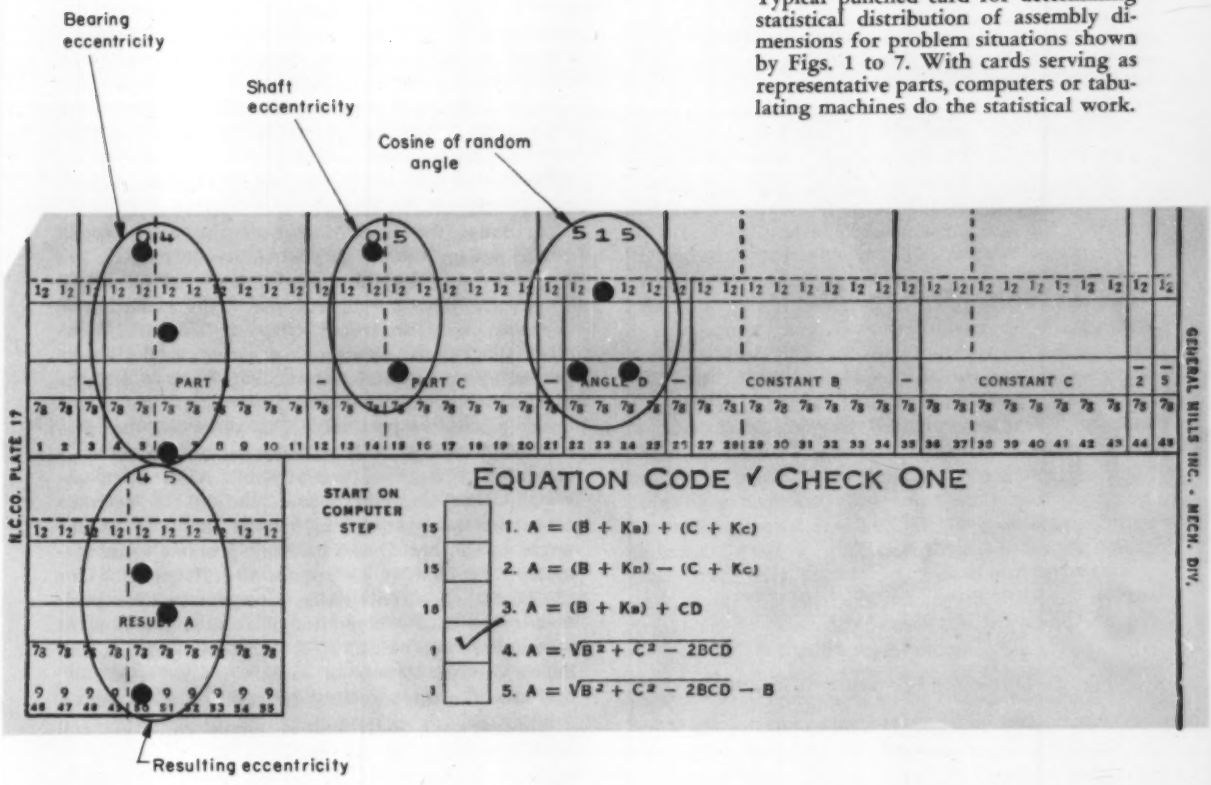
ideas

Helical-spring worm absorbs shock and isolates vibration in a light-duty speed-reducer design reported by Ernest Hexman, Cleveland. Worm consists of a spring that is wound with open coils in the center and closed coils at each end. The last coil on each end of the spring is open to permit fastening to the shaft. The worm shaft is reduced in diameter through the meshing area to avoid interference with the worm gear.

Radioactive sensing element detects minute changes in liquid level. Developed by the Aeronautical Division of the Robertshaw-Fulton Controls Co., the design permits accurate liquid-level regulation under extremes of temperature, vibration and shock. The beta source for high-speed electrons and the beta detector, a geiger-mueller tube, are separated by a small cavity that the liquid may flow into. When liquid is not present, radioactive particles pass from the beta source to the detector tube. When liquid is present in the cavity, the radioactive particles are absorbed, reducing the level of radiation at the detector. This radiation change is converted into an electrical signal and amplified for use.







Typical punched card for determining statistical distribution of assembly dimensions for problem situations shown by Figs. 1 to 7. With cards serving as representative parts, computers or tabulating machines do the statistical work.

An easy approach to

Statistical Tolerancing

with punched-card computers

By Richard L. Thoen

Staff Engineer, Mechanical Div.
General Mills Inc., Minneapolis

TRADITION and human inertia have been largely responsible for the wide-spread neglect accorded the matter of product tolerances. As a consequence many drawing specifications are incomplete, redundant, meaningless and unnecessarily close. Likewise, product parts are made and inspected according to so-called "practical" interpretations of these unrealistic specifications. Much has been said of this incongruous state of affairs. For example, Juran[1] says:

"In retaliation [for parts failing to meet specified tolerances], the engineering department will deliberately set tolerances tighter than warranted by experiments . . . This practice is in turn suspected or discovered by manufacture. Then there develops a game of guesswork, the designers wondering how much to tighten up to allow for looseness in the shop, and the shop wondering how much looseness actually exists in the designs."

To avoid this dilemma, it is necessary (but certainly not sufficient) to specify product tolerances that are just as liberal as assembly functional requirements will permit. For interchangeable man-

[1]References are tabulated at end of article.

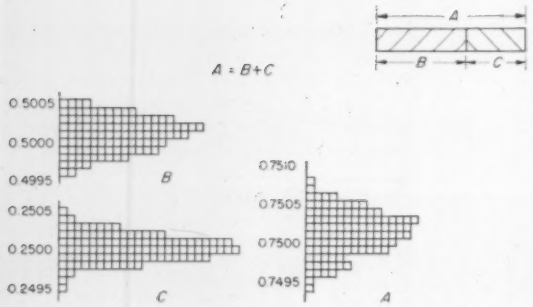


Fig. 1—Sum of two lengths.

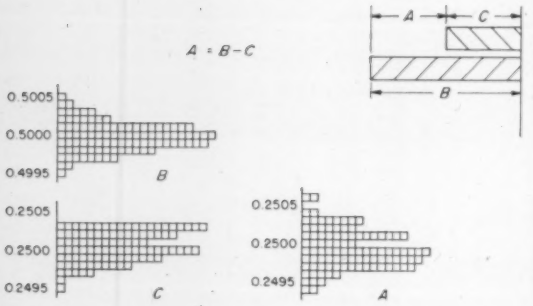


Fig. 2—Difference between two lengths.

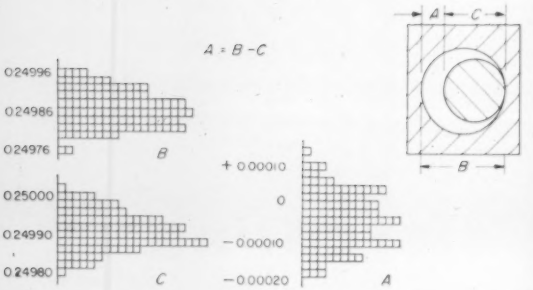


Fig. 3—Cylindrical fits.

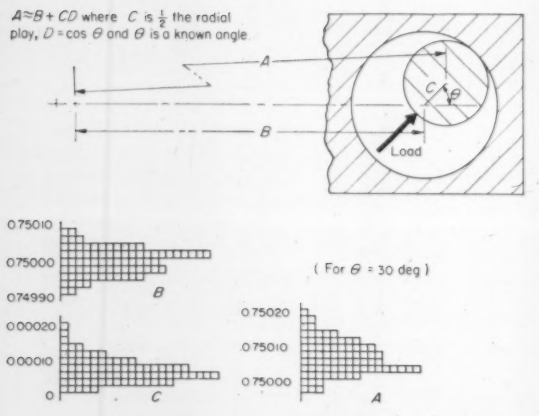


Fig. 4—Effect of radial play.

ufacture, this criterion means tolerances based on probable rather than additive combinations. Accordingly, at first glance it would seem that designers should be familiar with those parts of probability theory that have to do with how tolerances combine. But statistical training is a luxury. Even with some knowledge of probability theory, realistic answers to the ordinary real-life tolerancing problems shown in Figs. 1 to 7 are not always easy to obtain.

Actually, for most designers the necessity of being well-grounded in probability principles has been obviated by the large number of electronic computers now in general use. This situation is perhaps best illustrated with an example. Consider the common case of an eccentric shaft supported by an eccentric mount, Fig. 6. Here, lengths B and C represent eccentricities of the outer and inner pieces, respectively. The observed distributions for values of B and C are quite skewed, a condition typical of eccentricity. Also, upon assembly, the angular phase relationship between eccentricities B and C is just as likely to be one angle as another. It is a difficult problem in mathematical probability to predict the distribution for the combined eccentricities. However, with a business or scientific computer it is a simple matter to combine the values of B and C at random, calculate the eccentricity of each individual assembly, and tabulate the resulting distribution of A values.

Normally, an individual assembly condition can be represented by a relatively simple algebraic expression. Moreover, as can be seen from Figs. 1 to 7, routine design work requires only a few so-called "assembly equations." That is, one equation is required for the sum and difference of two lengths, another for the effect of radial play and eccentricity, etc. In other words, a computer can be programmed once and for all to handle a large variety of tolerancing problems. Thus, in the electronic computer, the designer has at his disposal a very realistic "assembly simulator." To cite a specific instance, a simulation procedure

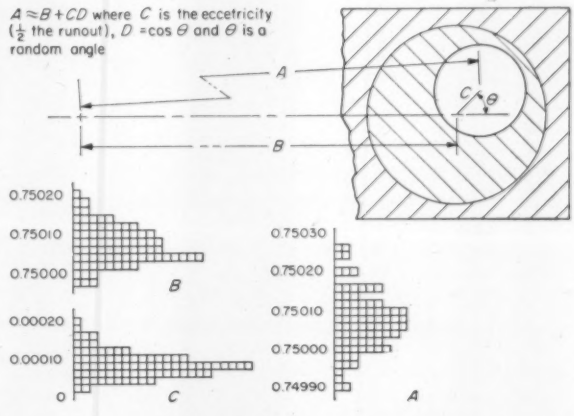


Fig. 5—Effect of eccentricity.

which is adaptable to punched-card accounting machines of the type commonly used to process pay rolls, cost accounting, inventory, etc., is as follows:

One of the two distributions is key-punched into a set of cards. For example, in Fig. 1 the dimension 0.5005 is punched in four cards, 0.5004 in ten cards . . . and 0.4996 in two cards. The deck is then mechanically shuffled (randomized) either on a key-punch verifier or on a collator. Next, the second distribution is punched into the same cards in a like manner.

If random angles are involved, as in Figs. 5, 6 and 7, then the cards are also fed into a reproducing-punch, which duplicates the cosine of the random angle from a mixed master deck containing a sufficient number of equispaced angles between 0 deg and 360 deg. Then, the cards—each one of which now represents an individual assembly—are sent through a computer (such as the UNIVAC 60, IBM 604, etc.) which has been programmed to calculate the assembly condition and punch the answer. If only addition or subtraction is required, as in Figs. 1, 2 and 3, a tabulating machine can be used instead of the computer.

The cards are then grouped according to answers on a sorting machine and, finally, fed through a tabulator which prints the resulting distribution. If the results of the simulated assembly are not satisfactory, then it is only necessary to modify the input information and rerun the problem.

Generally speaking, simulation of an assembly process on a computer—as compared with idealized statistical mathematical relationships—is a simpler procedure and results in a much more realistic representation. As in the foregoing example, it is possible for the number of cards to equal the number of actual parts—which is as it should be. Otherwise the simulation is not a true representation of the assembly process. With large lots, however, it usually is not necessary to work with more than about 100 cards, since the effect of using additional cards may not be significant.

Another advantage of the computer over mathematical methods is that there is no restriction on the forms of distributions that can be handled. In practice, a great many manufacturing distributions do not follow the normal distribution curve. Examples are radial play, eccentricity, sorting operations (see Fig. 2, C values), small quantities of parts, etc. Moreover, distributions that could be normal are often not normal—such as OD's and ID's of ball bearings. Also, whenever the drawing tolerance is greater than the inherent capability of the process (natural tolerances), the part distribution may or may not fall in the center of the drawing tolerance. Actual distributions, or if they are not available, at least distributions on representative parts, can and should be used. This becomes especially important when the drawing tolerance is appreciably greater than the natural tolerance.

As was stated previously, basing product tolerances on probable rather than additive combinations is a necessary but not a sufficient condition for efficient manufacture. Other members of the industrial family must put their houses in order too. However, if the designer does not perform his part, then whatever accomplishments others in the organization may attain will be of small consequence. Or, as Buckingham[2] says:

". . . the task of dimensioning the detail drawings of the components for mass production is not a job for the office boy or an apprentice draftsman. The best production engineering talent in the organization will find full scope for the application of all the knowledge and experience available in this task. There is probably no other place in the organization where so much money can be saved by careful attention to detail, and there is certainly no other place where so much money can be wasted by carelessness and ignorance."

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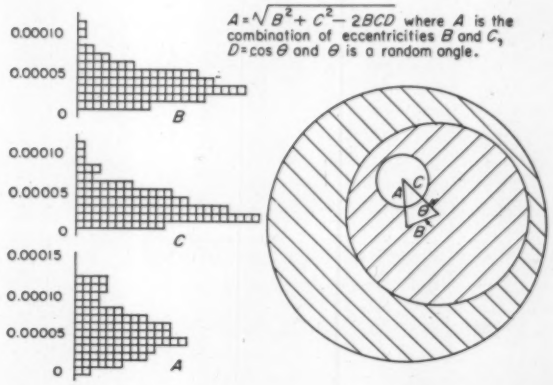


Fig. 6—Combination of eccentricities.

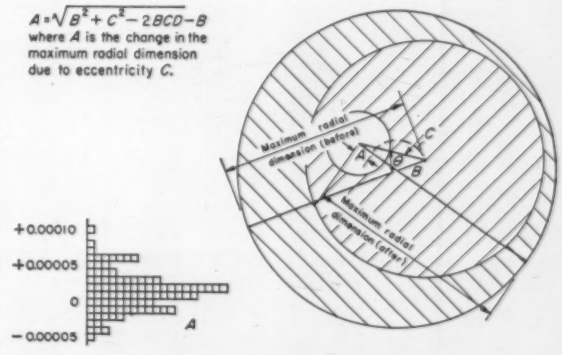


Fig. 7—Effect of an eccentric mount upon the maximum radial dimension of an eccentric cylinder. Values for B and C are the same as for example in Fig. 6.

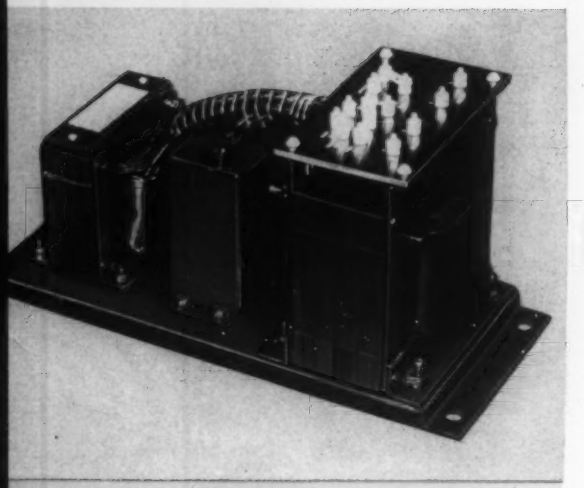
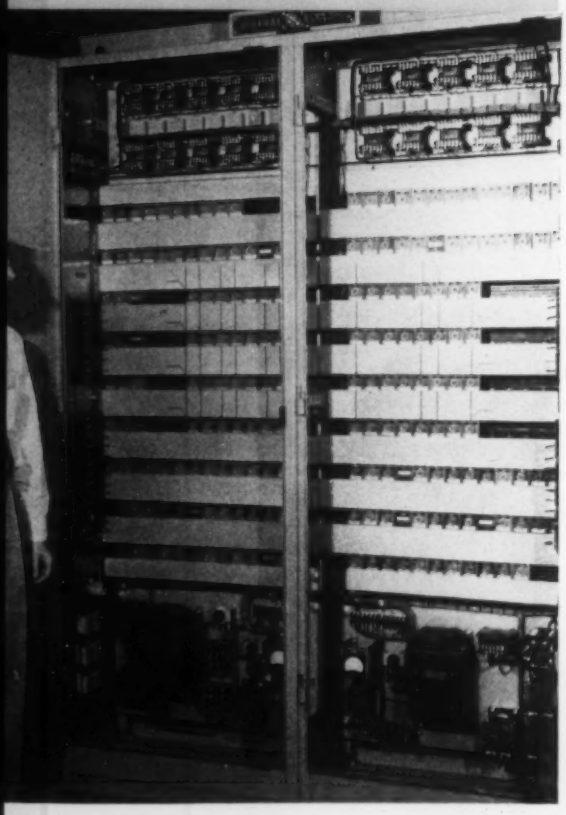


Fig. 1—Voltage stabilizer with multiple-output voltage taps for simultaneous control of voltage to several independent loads. For fixed, unity-power-factor loads, voltage to one load can be stabilized to within ± 1 per cent and to ± 3 per cent to the other loads.

Fig. 2—Static switching system control panel employing voltage-stabilizing transformers to help prevent malfunctions that might be caused by large voltage changes.



How design and operating characteristics of

Voltage-Stabilizing Transformers

affect selection and application

By David E. Musgrave
Specialty Transformer Dept.
Apparatus Div.
General Electric Co.
Ft. Wayne, Ind.

ELECTRIC power of uniform high quality is fast becoming a basic specification in design. Such factors as voltage spread, voltage level, power factor, and stability must be determined in the early stages of design to assure required motor torques, uniform electric-heat output, proper response of voltage-sensitive control devices, correct illumination, long equipment life, and power-bill economies. Supplying constant voltage to machines, equipment and instruments of all types is often the secret of efficient and uninterrupted operations. Voltage-stabilizing transformers can help perform this function, Figs. 1 and 2.

Why Voltage Varies

The voltage level of an electrical system is usually constant at its source or can be controlled within reasonable limits with load tap-changing transformers or voltage regulators. But, conditions between the source of constant voltage and a load frequently cause the voltage to vary as much as 15 per cent. Reactance in distribution systems causes the voltage level to change as intermittent loads, such as elevators, pumps or other motor-driven equipment, are connected or disconnected. Lightning causes line voltage to drop as the charge bleeds off through arresters. Switching disturbs the voltage level temporarily. The result of all

these disturbances is a varying voltage at the load.

Effects of Voltage Variations

Varying voltage seriously affects the operation of sensitive equipment—electronic, testing, computing, etc.—causing characteristics to change and equipment to operate improperly or fail. Even common devices do not operate efficiently if supplied with other-than-rated voltage. Lower-than-rated voltage decreases the output of lamps, motors, and heating devices; both undervoltage and overvoltage decrease efficiency and equipment life, causing increased maintenance costs, increased down-time and decreased production.

It pays to maintain voltage at rated levels and, as indicated in Table 1, it is apparent that stable voltage gives more efficient performance of equipment and longer service life of vital components. Many types of equipment can be designed to operate satisfactorily over a wide range of voltage by using components having special voltage tolerances. However, this technique increases the cost of components, and it is generally more economical to stabilize input voltage and use standard components.

Method of Stabilization

A varying supply voltage can be stabilized automatically and almost instantly by a circuit containing the proper combination of inductance and capacitance. The principle of operation is similar to that of using capacitors to "hold up" the voltage of a transmission line. The current drawn by the capacitors counterbalances the inductive characteristic of the transmission line to cause a voltage rise at the load, Fig. 3. By adjusting the capacitors to draw the correct amount of current, the voltage rise can be controlled and the voltage at the load brought within the desired limits.

A voltage-stabilizing transformer has comparable circuit parameters but its source of a variable capacitive current is provided automatically by a parallel combination of fixed capacitance and nonlinear inductance, Fig. 4. The circuit components can be physically separated and connected, as in Fig. 4, or they can be coupled magnetically, Fig. 5. For the latter type, the secondary winding and the transformer core provide the nonlinear inductance while the leakage inductance between the primary and secondary windings provides the fixed inductance. The compensating winding is added to improve stabilization.

Design

Voltage-stabilizing transformers are similar to conventional transformers in that the output is isolated from the input and a voltage transformation can be achieved in addition to the stabilizing

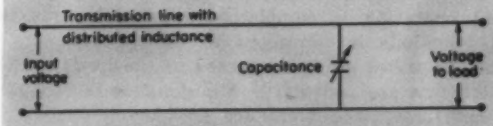


Fig. 3—Equivalent circuit of a transmission line with distributed inductance. The capacitor is added to correct voltage. Voltage to load can be held at desired level by manually varying the capacitance.

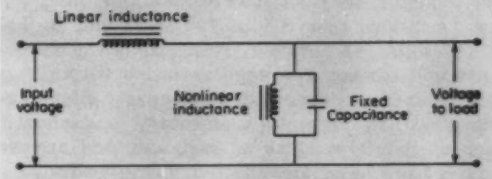


Fig. 4—Equivalent circuit of a voltage-stabilizing transformer that has parameters comparable to the transmission-line equivalent circuit in Fig. 3. Voltage to load is held at desired level automatically by the parallel combination of fixed capacitance and nonlinear inductance.

Table 1—Effects of Undervoltage and Overvoltage on Operation of Electrical and Electronic Equipment

Equipment	Undervoltage	Overvoltage
Induction Motors	10 per cent undervoltage decreases starting and maximum running torque 19 per cent, and increases temperature rise 12 per cent.	10 per cent overvoltage increases torque 20 per cent, increases starting current 11 per cent, and lowers power factor about 5 per cent.
Electronic Equipment	More than 5 per cent undervoltage seriously reduces cathode emission, circuits lose power capacity, and cathodes of gas-filled tubes may be destroyed in minutes.	5 per cent overvoltage reduces cathode life about 50 per cent. Slight overvoltage is usually preferable to undervoltage.
Lamps		
Incandescent	10 per cent undervoltage lowers light output 30 per cent.	10 per cent overvoltage reduces lamp life 70 per cent.
Fluorescent	10 per cent undervoltage decreases light output about 10 per cent; often results in unsatisfactory starting and shorter lamp life.	Overvoltage reduces luminous efficiency; over-current operation may shorten lamp life.
Mercury-vapor	10 per cent undervoltage reduces light output as much as 30 per cent; lamps may go out.	As little as a 5 per cent overvoltage overheats lamps, shortens their life, and may damage lamp transformer.
Resistance Heaters	10 per cent undervoltage drops output about 19 per cent.	More than 5 per cent overvoltage may significantly shorten life of high-temperature heating units.
Infrared Heating	Undervoltage causes a nearly proportional drop in infrared output; lengthens processing time.	Overvoltage causes a nearly proportional increase of infrared output; may damage the product in temperature-sensitive processes.
Capacitors	10 per cent undervoltage cuts by 19 per cent the kilovars that capacitors can supply for correcting power factor.	Overvoltage shortens life of capacitors.

feature. They are easy to build into equipment, and operation is completely automatic. One set of terminals is connected to the voltage supply and the other set is connected to the load; no adjustments are necessary. Maintenance is virtually nonexistent since there are no moving parts.

This type stabilizing device is normally applied in circuits rated at 10 kva at 600 volts and below although special applications are made for higher capacitities and voltage levels. Conventional units are capable of stabilizing an input-voltage change of 30 per cent or less to tolerances of ±1 per cent. For example, on a 115-volt system, all input-voltage variations from 95 to 130 volts will be held to 115 volts, ±1 per cent. Response is rapid; most units will correct a voltage variation within 2 cycles. This characteristic is particularly advantageous since it prevents momentary disturbances, such as inductive kicks or switching and arc-over surges from being transmitted to the load.

Operating Characteristics

Stabilization is the degree to which an output-voltage level is held constant under specific conditions of input-voltage variation, frequency, load, load power factor, and operating temperature. These characteristics, plus the manufacturing tolerance involved when setting the ratio of voltage transformation, independently and collectively affect the level at which the voltage is stabilized and the variance from this level. Thus, when describing the output of a voltage-stabilizing transformer, it must be assumed that all factors are within normal limits or at known values.

Types of Loads: Most voltage-stabilizing transformers are designed to maintain the rated output voltage to within ±1 per cent at rated load for an input-voltage variation of 30 per cent or less. Table 2 shows the change in output-voltage level caused by changing from rated load to no load. Variation from the level is held to ±1 per cent. Output-voltage levels for various loads are shown in Fig. 6.

For less than rated loads, as Fig. 6 shows, the output-voltage level remains close to nominal for an extremely wide range of input voltages. This means that by operating a standard voltage-stabilizing transformer at less than rated load, the range of input-voltage variation can be extended to more than 30 per cent and the output still held to within ±1 per cent. For example, a unit

Table 2—Variations in Output-Voltage Level for Load Changes from No-Load to Rated

Voltage-Stabilizing Transformer Capacity (va)	Approx. Change in Output-Voltage Level (per cent)
50 and below	3
50 to 250	2
255 to 750	1½
750 and above	1

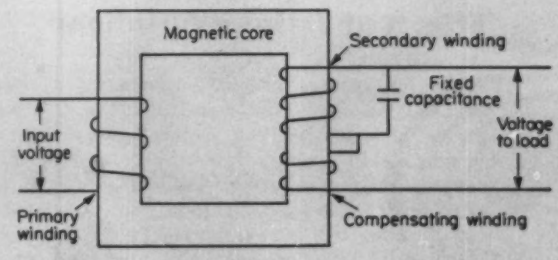


Fig. 5—Circuit diagram of a typical voltage-stabilizing transformer. Leakage inductance between primary and secondary windings provides the linear inductance for the circuit; the secondary winding and the core structure provide the nonlinear inductance.

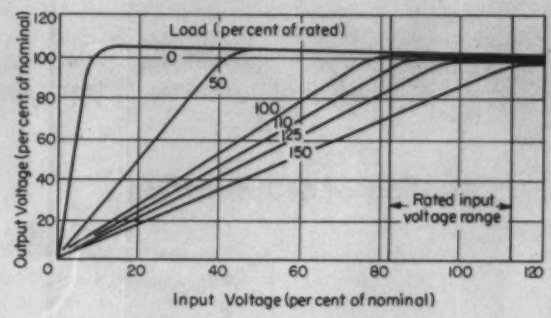


Fig. 6—Voltage-stabilization characteristics of a typical standard unit operated into various loads set at nominal output voltage. Load impedances were unchanged as input voltage to the voltage stabilizing transformer was varied from 0 to 120 per cent.

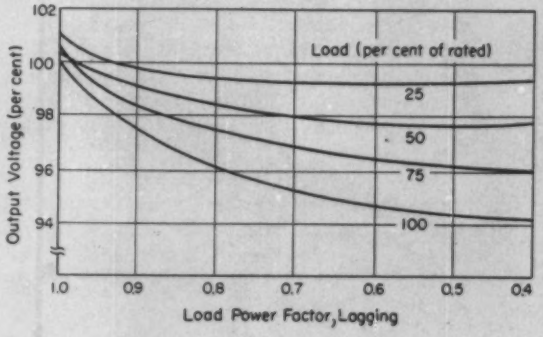


Fig. 7—Effects of load power factor on output-voltage level of a typical standard voltage-stabilizing transformer.

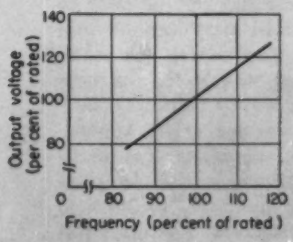


Fig. 8—Effects of frequency changes on output voltage of a typical standard voltage stabilizer.

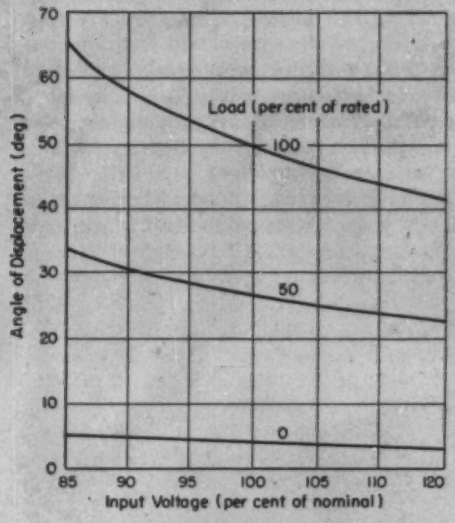


Fig. 9—Chart showing how phase displacement between input and output voltages of a voltage-stabilizing transformer varies with load and input-voltage level.

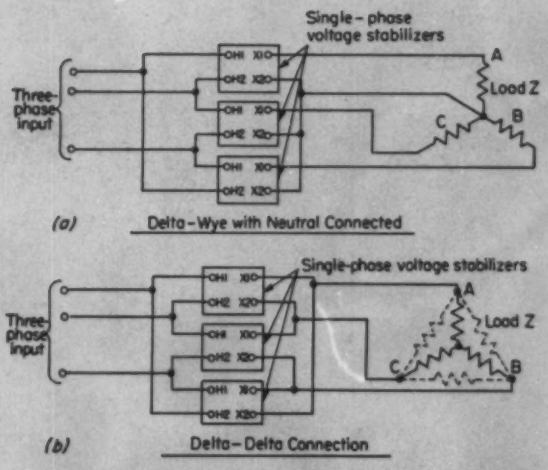


Fig. 10—Connection diagram of three single-phase voltage-stabilizing transformers connected delta-wye with neutral solidly connected to load, *a*. In *b* is a connection diagram of three single-phase voltage-stabilizing transformers connected delta-delta; load can be connected delta (shown in dashed lines) or wye.

applied at half load will stabilize an input-voltage variation of approximately 55 per cent.

Load Power Factor: The output-voltage level of standard voltage-stabilizing transformers is affected by load power factor, Fig. 7. Some applications require special voltage-stabilizing transformers that are compensated for lower-than-unity power factor or are insensitive to changes in power factor. Typical examples are motor and fluorescent ballast test equipment where the test voltage must remain constant as the load power factor changes; otherwise, erroneous tests will result. Another example is an inductive load that operates at less than rated voltage because low power factor has reduced the output-voltage level of the stabilizer.

There are various ways to design voltage stabilizers to compensate for less-than-unity power-factor loads. When the load power factor is fixed, the voltage-stabilizing transformer can be designed for a voltage ratio to give the required output-voltage level; or a standard voltage-stabilizing transformer can be used with a capacitor in parallel with the load to give unity power factor.

For a load having a variable power factor, a voltage-stabilizing transformer can be specified that incorporates power-factor compensation. This type unit will stabilize the output voltage to within 1 per cent even though the power factor varies from 40 per cent lagging (inductive) to 40 per cent leading (capacitive).

Frequency: Voltage-stabilizing transformers are normally designed to operate at fixed power frequencies. The effect of frequency on the output-voltage level is shown in Fig. 8. Other factors being constant, the degree of stabilization is ± 1 per cent at the level determined by the frequency. For special applications, such as diesel-driven generators where the supply frequency varies within the range of ± 5 per cent, special units can be designed to hold the voltage level constant within ± 1.5 per cent. These special units must be used only for operation at rated load and rated-load power factor; otherwise the circuit may become unstable.

Effects of Temperature: The output-voltage level of a voltage-stabilizing transformer will decrease with an increase in temperature. Since they are normally designed to operate over an ambient temperature range of -25 to 40 C with a temperature rise of 55 or 80 C, a noticeable change in the voltage level could occur. To allow for this variation, manufacturers usually assume an average ambient temperature of 25 C and set the output at the correct level for the operating temperature, which is ambient plus temperature rise. Special units are recommended for ambient temperatures outside the prescribed limits.

Output-Current Limits: Another important operating characteristic of voltage-stabilizing trans-

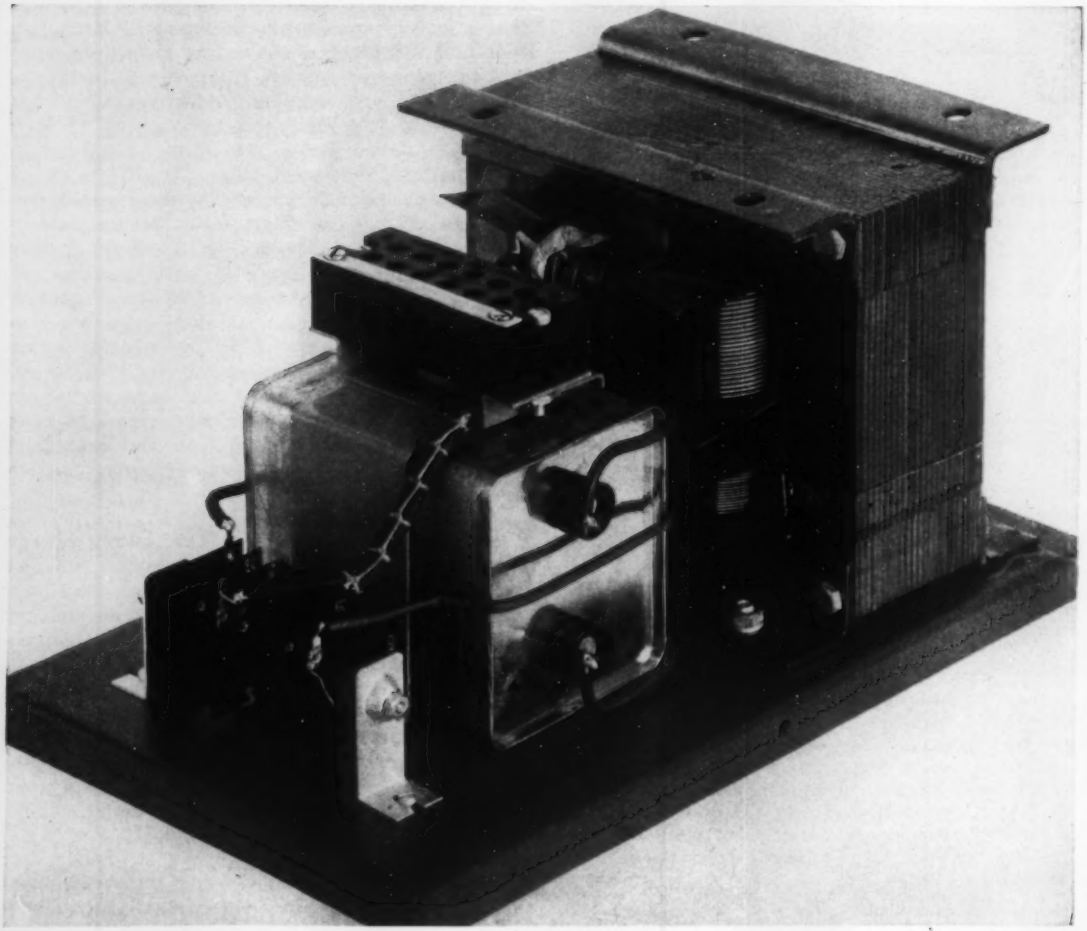
formers is that of limiting output current to approximately 140 per cent of rated. This not only protects the stabilizer and the load but prevents a short circuit from reaching the line. It is desirable to limit the inrush current of a tube filament. However, some loads, such as motors, inherently draw more than rated load when starting, so the current-limiting feature must be considered in the design specifications sent to the stabilizer manufacturer. The voltage-stabilizing transformer must be rated to carry the starting load. Fig. 6 shows that the output-voltage level drops as load exceeds rated. At a critical point, the output voltage collapses. At short circuit, the input and output currents vary directly with the input voltage.

Voltage Waveshape: In a voltage stabilizing transformer the voltage waveshape contains harmonics of the system frequency caused by the inherently high magnetic density required by the secondary core structure. The amount of the harmonic content is a function of the input voltage and the load. Table 3 indicates the harmonic content under various conditions and can be used to determine whether a standard unit can be employed for the application. The nearer the stabilizer is operated to full load, the lower the harmonic content of the output wave. Normally, harmonics are unimportant except for a few applications requiring a perfect sine wave. For these cases, units with harmonic filters should be specified.

Because the output waveform of voltage-stabilizing transformers is not purely sinusoidal, certain voltmeters will not measure the output voltage accurately. Rectifier meters, since they are calibrated for pure sine-wave form, will give readings that are 6 to 10 per cent high. Iron-vane meters in general are not recommended. To get accurate readings, use a dynamometer type voltmeter having reasonable accuracy up to 500 cycles per second.

There is an inherent phase displacement between the input and output voltages of most static type

Fig. 11—Dc power supply using a voltage stabilizer and a germanium rectifier. This unit provides 225 v, ± 1 per cent of dc at 2 amperes.



stabilizing devices. The amount of displacement for voltage-stabilizing transformers depends upon the input voltage and the load, Fig. 9.

Application Data

From the foregoing it is apparent that voltage-stabilizing transformers must be applied under specific operating conditions; otherwise, the output-voltage level and degree to which the level is held constant will not be satisfactory. However, if it is known how operating conditions vary from normal, compensations can be made in the system to give satisfactory results.

Parallel Connection: When greater-than-rated capacity is needed, it is often desirable to connect voltage-stabilizing transformers in parallel. For example, if a load requires a kva size between standard ratings, two or more standard units can be connected in parallel to match the kva requirement. Parallel voltage-stabilizing transformers must have identical voltage and frequency ratings; however, the kva ratings can be different.

Voltage Level: Standard units are made with a ratio of 115/115 volts or for series-multiple 115/230 to 115/230 volts. Other voltage transformations are often required, for example, 6.3 volts for electron-tube filament heating from a 115-volt source. Where space is a premium, it is common practice to build the special voltage transformation into the voltage-stabilizing transformer. However, in some applications it may be more economical to use a separate step-up or step-down transformer along with a standard stabilizer.

In many cases, separate transformers can be used to adjust a low voltage to the desired level. For example, assume that the output-voltage level of a voltage-stabilizing transformer has been lowered 5 per cent by a lagging power factor. The voltage can be raised to the desired level with a buck-boost transformer connected for a 5 per cent boost.

Another method of solving the problem of voltage level is to use a voltage-stabilizing transformer having taps for multiple output voltages, Fig. 1. Thus as load conditions change, the voltage can be adjusted to the correct level simply by changing taps. Two or more independent loads, such as plates and filaments of electron tubes, can be stabilized simultaneously from a single-input voltage-stabilizing transformer having multiple output windings. For this type unit, one load can be held to ±1 per cent while the tolerance for other loads is 3 per cent. These levels can be held only if the loads are supplied simultaneously; if one or more loads are removed, the voltages to the remaining loads will be stabilized at slightly higher than normal levels. For applications requiring a number of closely regulated voltages, it may be more economical to use a standard voltage-stabilizing transformer and a separate multiple-output, step-down transformer. The step-down unit could be included in the same housing with the stabilizer or mounted separately, depending on space and cost considerations.

Table 3—Total Harmonic Content in Typical Voltage-Stabilizing Transformer

Input Voltage (per cent nominal)	Harmonic Content in (per cent of fundamental)	
	Full Load	Half Load
85	9	21
100	16	26
115	21	30

Three-Phase Circuits: The application of voltage-stabilizing transformers in three-phase circuits requires special attention to the type circuit used, nature and balance of load, and required output voltages. Since unexpected interaction may occur between the various phases to give undesirable results, it is recommended that selection and specifications be made upon the advice of the manufacturer. The following is intended only as a guide in determining if voltage-stabilizing transformers connected three-phase will meet a given set of specifications.

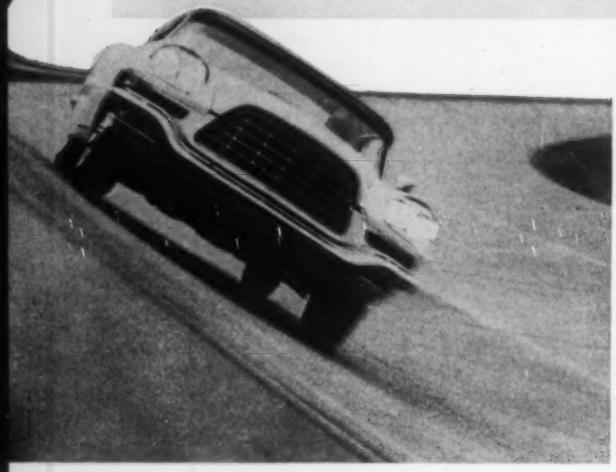
Standard single-phase stabilizers can be operated in three-phase banks with stabilizer inputs connected delta, outputs connected wye with a neutral, and supplying a wye-connected load where neutral is connected to stabilizer neutral, Fig. 10*a*. Resonably stable operation is obtained from rated load to no load with balanced loads. Unbalanced phase currents cause appreciable unbalance of line-to-line voltages; however, stabilization of respective line-to-line voltage levels is reasonably good.

Delta-delta connection of three single-phase voltage-stabilizing transformers is shown in Fig. 10*b*. Since the delta provides a closed path for the flow of harmonics, special units only, having low harmonic characteristics and extra allowances for heating, can be used.

Rectifier Circuits: If voltage stabilizers are applied to rectifier circuits, Fig. 11, consideration must be given to the shape of the output wave from the stabilizer. The output approaches the shape of a square wave, which is actually beneficial to the application since it requires less filtering than the conventional sine wave. The form factor of the wave is approximately 1.25 to 1 rather than 1.414 to 1 for the sine wave. This means that the stabilizer peak voltage is lower than expected and must be considered when choosing the required ac voltage input to the rectifier bank. Special voltage-stabilizing transformers with the proper ac output can be provided.

For applications where circuit components can not be changed to compensate for the form factor, voltage-stabilizing transformers with harmonic filtering can be specified. The output of this type unit, for practical purposes, is a sine wave and, when used with a previously designed circuit, will not disturb the established voltage levels.

Mechanics of Vehicles-2 Cornering



By Jaroslav J. Taborek*
Development Engineer
Towmotor Corp.
Cleveland

DIRECTIONALLY stable maneuvering of self-propelled vehicles presupposes the ability of tires to support side forces developed by centrifugal effects, side winds and road-bank elevations. Research in the mechanics of tire cornering is of relatively recent date, and advanced development is still in process. The unusual complexity of the subject permits treatment here of only basic principles. Detailed considerations are presented in references given at the end of the article.

Tire Action in Cornering

Rigid wheels give sufficient stability to a low-speed vehicle steered by outside forces. The horse and carriage is an example. An automotive vehicle steered from within, on the other hand, maintains directional stability at high speeds only by utilizing the much higher side-thrust capacity of a rubber tire.

Cornering Forces: Rolling motion of a wheel is obviously possible only in its longitudinal plane. If by action of external side forces, the travel direction of a wheel is forced to deviate from true rolling direction, the rubber tire counteracts with a frictional-reaction or cornering force, Fig. 7. Condition for its existence is an area ground contact, which contrasts with the linear contact of a rigid wheel. The tire cornering force originates in the elastic forces of rubber-tire particles which, as they pass the ground-contact area, are forced to travel sideways in addition to their rolling progression. Conversely, the tire will develop a cornering force only if its path of travel deviates from the true direction of rolling. Cornering force is, in fact, proportional to the angle of deviation or slip angle.

Necessary consequence of this phenomenon is that the course of a vehicle negotiating a curve must differ from the theoretical path of rolling by the value of slip angle required to create the necessary cornering force. The relation between slip angle and cornering force gives rise to the practice where front or steering wheels are turned in toward the center of the vehicle at a small angle called the toe-in angle. For straight-ahead driving, toe-in angle is actually slip angle. This angle enables the steered wheels to absorb side thrusts and road shocks without deviating from a straight course. If the same deflecting forces act on a wheel without toe-in, the tire must create its slip angle with consequent directional change.

It is of fundamental importance that the hypothetical action point of the cornering force fall (in relation to the travel direction) behind the projected wheel center. The cornering force then exerts on the tire a horizontal torque which tends

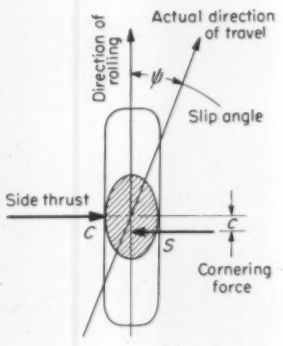


Fig. 7—To balance side thrust *C*, the rubber tire develops a cornering force *S* when its direction of travel deviates from the true rolling plane by slip angle Ψ.

*Now Research and Development Engineer, Phillips Petroleum Co., Bartlesville, Okla.

and Directional Control

- cornering forces
- self-aligning torque
- wheel-ground orientation
- static-steering torque

to decrease the existing slip angle and therefore realigns the directions of rolling and actual travel. This particular effect of cornering force is known as the *self-aligning torque.*

Factors Influencing Cornering Force: From the physical origin of cornering forces, factors influencing its magnitude can be deduced. Tire behavior in cornering is usually represented by characteristic curves like those shown in Figs. 8 through 12. These curves are presented to emphasize character of the functions rather than actual numerical values.

Principal factors affecting the cornering force are presented in following sections.

SLIP ANGLE: Cornering force is proportional to slip angle, Fig. 8. The function is practically linear up to about 5 deg slip; it then flattens out and reaches maximum value where the tire starts to skid. To aid comparison of cornering behavior of different tires, the factor *cornering power,* defined as cornering force per deg slip angle, has been introduced. The cornering power of an average passenger-car tire is about 150 lb per deg slip angle.

RADIAL LOAD: Cornering force, since it is basically frictional in character, is proportional to the radial weight acting on the wheel. Tire deformation and changes in contact-area pressure distribution cause the function to deviate from the theoretical straight line. Maximum value falls near the nominal load point, Fig. 9.

For better comparison purposes, the combined factor, *cornering coefficient,* was created, defined as cornering power per unit vertical load. This factor is used as a true measure of the interrelation between load and cornering ability. The form of the curve indicates that relative cornering capacity declines with higher loads or, in other words, the more load a tire carries, the less effective it is in supporting side forces, Fig. 10.

CAMBER ANGLE: A cambered wheel—one with

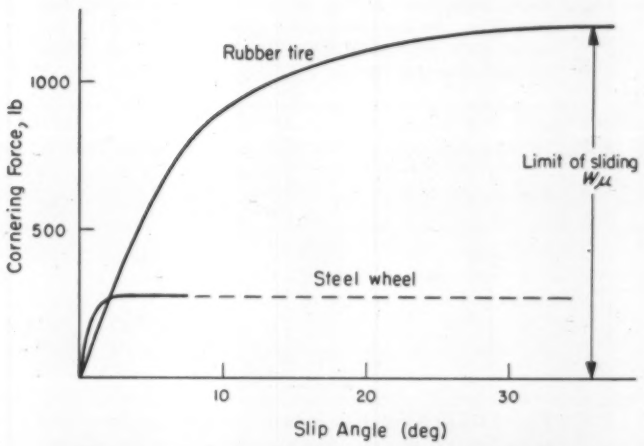


Fig. 8—Cornering force as a function of slip angle for typical rubber-tired and steel wheels. Force reaches maximum value $W\mu$ where skidding begins.

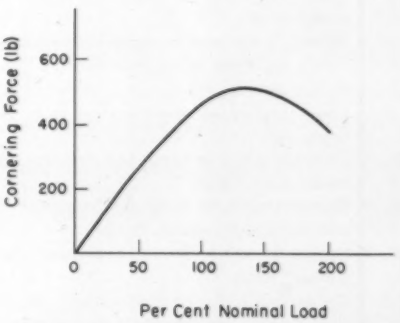


Fig. 9—Cornering force as a function of radial load (3-deg slip angle). Tire deformation and changes in footprint pressure distribution cause function to deviate from the theoretical straight line.

its plane of rotation angled away from the perpendicular—would follow a circular rolling path if not restricted. Direction of travel of a cambered wheel on a vehicle therefore deviates from its natural rolling path, creating a slip angle and, consequently, a cornering force. Value of this force is, for the usual camber angles of about 1 deg, relatively small. It subtracts or adds to the cornering force due to the centrifugal effect, depending on whether the camber inclination is toward or away from the inside of the curve.

INFLATION PRESSURE: Increase in side-wall stiffness accompanying higher inflation pressures results in an increase in cornering power. Higher inflation pressures are therefore often used to achieve better cornering effects, Fig. 11.

TIRE SIZE: Small tires have relatively higher cornering ability than large tires (per pound of load capacity). This accounts in part for the preference for small dual tires rather than single large ones.

SPEED: Cornering force has been found independent of speed.

Self-Aligning Torque: An important factor in steering behavior is self-aligning torque. Usually represented as a function of the slip angle, this factor shows a maximum around 5 deg slip angle, followed by a steady decline. For very high slip angles it reaches negative values.

The relation between cornering force and self-aligning torque is illustrated in Fig. 12. After the self-aligning torque has reached a positive maximum, it reverses and reaches a new high in the negative direction. Cornering force steadily increases with slip angle until the skidding limit W_μ is attained, Fig. 13. The average driver will

Nomenclature

A = Area, sq in.
b = Nominal tire width, in.
C = Centrifugal force (side thrust), lb
c = Action arm of cornering force, in.
e = King-pin offset (projected distance on the ground), in.
h = Effective moment arm of steered wheel, in.
I_o = Polar moment of inertia of tire footprint, in.^{4}
k = Polar radius of gyration of tire footprint area, in.
M_{ik} = Moment around king pin due to king pin inclination, lb-in.
M_k = Moment around king pin required to turn one stationary wheel, lb-in.
M_s = Static steering moment around footprint center, lb-in.
S = Cornering force or side thrust, lb
S_i, S_o = Side forces (subscripts i and o refer to inside and outside wheels, respectively), lb
W = Weight or load, lb
α = Steering angle, deg
θ = King pin inclination, deg
ψ = Slip angle, deg
μ_s = Coefficient of sliding friction
μ = Effective coefficient of friction of a steered tire

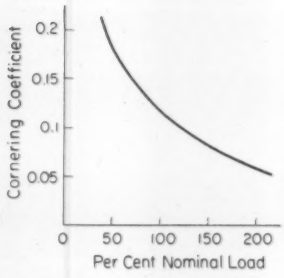


Fig. 10 — Cornering coefficient (cornering power per unit radial load) as a function of radial load. Curve shows that the ability of a tire to support side thrust decreases as the load it carries increases.

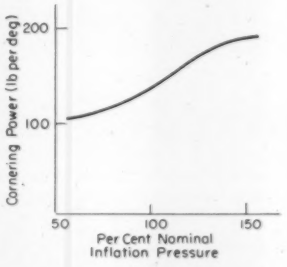


Fig. 11 — Cornering power as a function of inflation pressure.

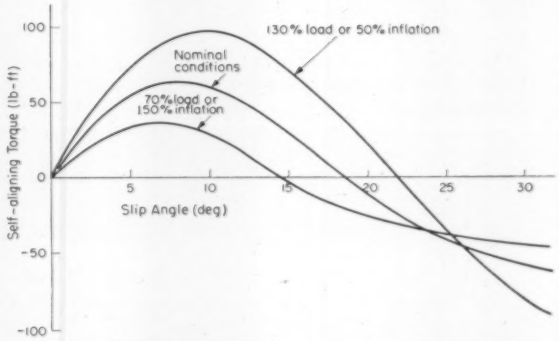


Fig. 12—Self-aligning torque as a function of slip angle. At high slip angles, self-aligning torque becomes negative, acting in a steer-angle increasing direction. Radial load and inflation pressure, because they determine footprint area, have an effect on self-aligning torque.

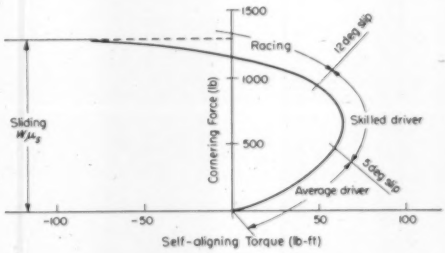


Fig. 13—Relationship between cornering force and self-aligning torque. Average driver can handle car at slip angles to 5 deg, skilled drivers to 12 deg. In racing, slip angles become high enough to give steer-angle increasing torques.

manage the car with slip angles up to 5 deg, skilled drivers up to 12 deg. If driving conditions require still higher cornering forces, extremely high slip angles must be used, and the field of negative self-aligning torque is entered. This effect often can be observed in auto racing, where the driver in a sharp turn steers against the track curvature.

Inflation pressure and radial tire load have an effect on self-aligning torque because of the way these variables change the footprint area. Higher loads and lower inflation pressures enlarge the area and the critical distance c (Fig. 7), consequently increasing the self-aligning torque.

Directional Control

Directional control is defined as the process of giving the vehicle a desired course. *Handling quality* is usually understood as the total of rather subjective impressions of the driver regarding behavior and response of the vehicle to directional commands.

Directional stability, on the other hand, is a dynamic property, implying the tendency of the vehicle to maintain a given course under the action of disturbing forces and its ability to create a new equilibrium condition after the disturbance has been removed. Despite the apparent importance of the problems of vehicle maneuverability, particularly at high speeds, systematic research in this field has been undertaken only in the last decade or so.

Wheel-Ground Orientation: The steered wheel is suspended to pivot around the king pin. Angular position of both wheel and king pin is of basic importance with respect to steering behavior and steering forces. Simplified illustration of a steered wheel is shown in Fig. 14. Description of the functions of wheel and king pin angles is given in the following sections.

TOE-IN: The wheel angle with the longitudinal axis of the vehicle is toe-in angle. It forms with the drive direction an actual slip angle, creating, therefore, side-thrust capacity for absorbing side shocks from the road and eliminating steering-wheel flutter known as "shimmy." Too high toe-in angles result in excessive tire wear and high rolling resistance. Toe-in angle is measured as a linear deviation of the wheel rim, with usual values of about $\frac{1}{8}$-in.

CAMBER: Angle of the wheel plane with the ground is described as camber. Opinions vary on its desirability and recommended magnitude. Its main purpose is to achieve axial bearing pressure and to decrease the king pin offset distance e. Camber on passenger cars is between $\frac{1}{2}$ and 1 deg. Too high camber angles promote excessive tire wear.

CASTER: King-pin angle in the longitudinal di-

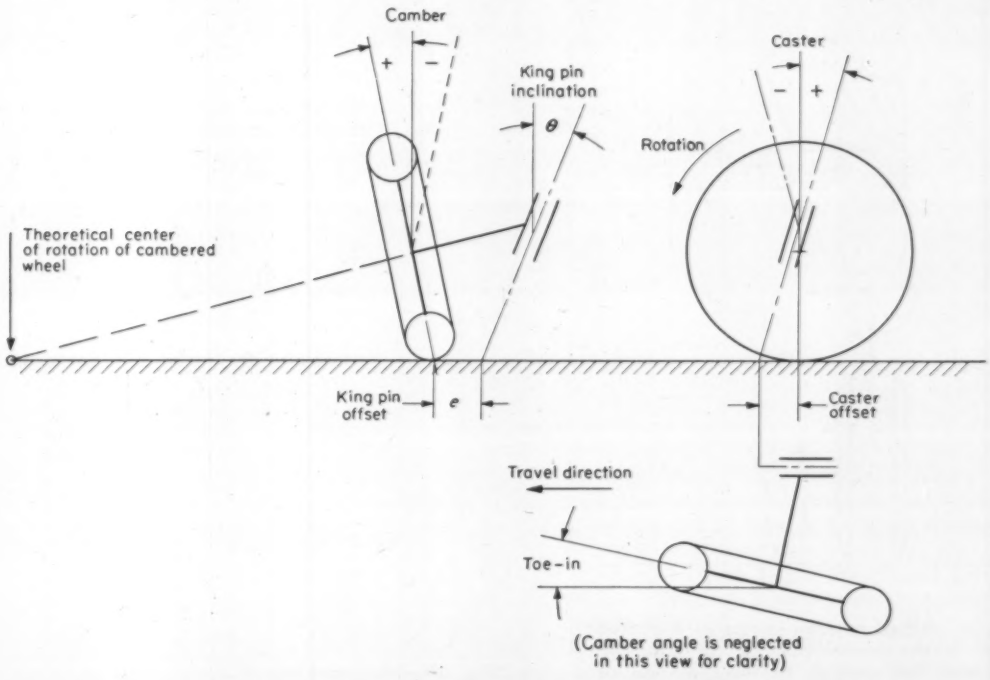


Fig. 14—Wheel orientation with the ground.

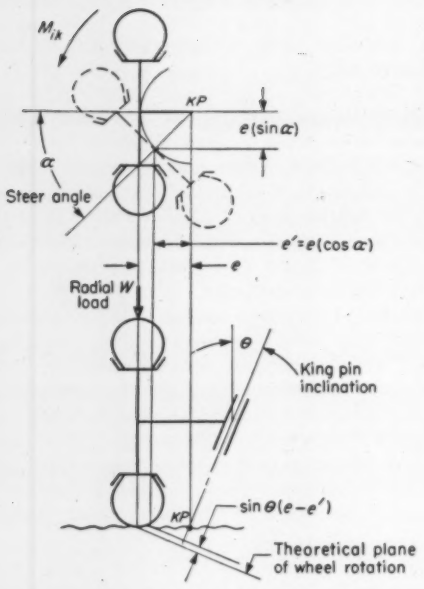


Fig. 15—Effect of king-pin inclination on steering. When wheel is turned around the inclined king pin, the axle is lifted, creating an unstable condition. Return to equilibrium is a self-aligning effect.

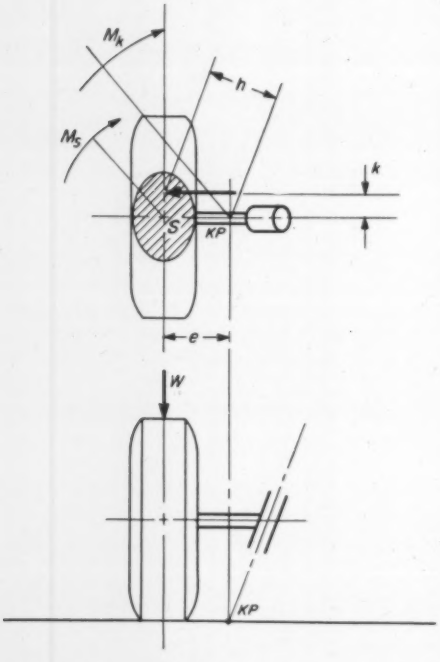


Fig. 16—Actual turning center of a steered wheel is the intersection of the king-pin axis with the ground. Steering motion of the wheel around this point combines wheel sliding and rotation.

rection is caster. It is positive if the ground intersection point relative to the travel direction is ahead of the projected tire center. Caster is used for the self-aligning effect it produces. Usual values are between 3 and 5 deg positive. On rear-axle steered vehicles, negative caster is applied.

KING-PIN INCLINATION: King pin angle θ, perpendicular to the direction of rolling, is king-pin inclination. This angle is used mainly to decrease king pin offset e and to achieve the self-aligning effect. When a wheel with an inclined king pin is turned, the whole axle must be lifted. The moment required to keep equilibrium at the steer angle α can be calculated from Fig. 15, as

$$M_{ik} = \frac{eW \sin\theta\,(1-\cos\alpha)}{\sin\alpha} \qquad (14)$$

The lifted axle represents, however, an unstable condition. When it trys to regain the low, stable position, a self-aligning torque is created. For the usual king pin inclination angles (about 6 deg) the self-aligning torque is relatively small.

Steering the Stationary Vehicle: The first problem in directional control is steering of the stationary vehicle. Fig. 16 shows the top view of a steered tire and king pin. Torque M_s required to turn the tire around its projected center S is the integral of the frictional forces of the footprint area. It can be calculated as

$$M_s = \mu_s W k \qquad (15)$$

where μ_s is the coefficient of sliding friction, W

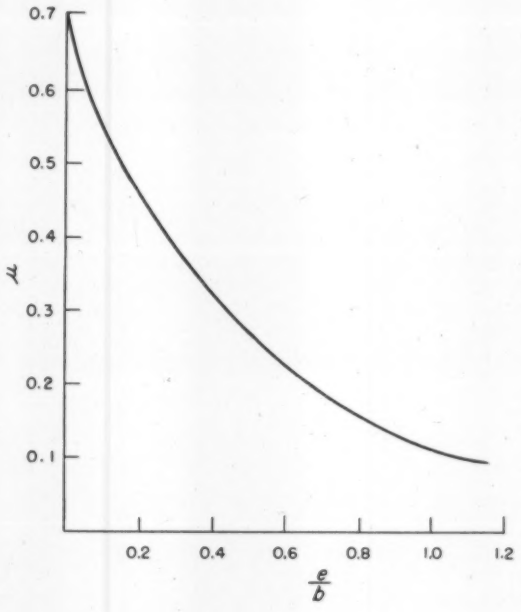


Fig. 17—Static-steering friction coefficient (stationary vehicle) as a function of ratio of king-pin offset to nominal tire width.

the radial load and k the polar radius of gyration of the footprint area.

Center of rotation, which is the hypothetical intersection of the king pin with the ground (point *KP*), is usually located at a distance e from the footprint center. Consequently, turning of the wheel around this point will not be pure sliding, but rather combined rolling and sliding. The rolling component will increase with larger e values. The effective torque arm becomes

$$h = \sqrt{e^2 + k^2} \qquad (16.1)$$

and the torque necessary to turn the wheel is

$$M_k = \mu W h \qquad (16.2)$$

Here, the effective friction coefficient μ is a function of distance e and of tire size. Approximate values of μ on dry concrete ($\mu_s = 0.70$) are represented in Fig. 17 as a function of the factor e/b, where b is the nominal width of the tire.

Values of k can be calculated from the actual tire footprint, which in turn, is a function of inflation pressure and radial load. In rough approximation, the footprint area is a circle, and for nominal tire load conditions, the diameter of this equivalent circle can be assumed equal to the nominal tire width b. The value of k can be then calculated from

$$k^2 = \frac{I_o}{A} = \frac{b^2}{8} \qquad (17)$$

where A is the area of the footprint, and I_o the polar moment of inertia of the area.

Static torque M_k is proportional to μ and e, while μ itself decreases with larger e values. This indicates that an optimum king pin distance e must exist for which M_k will be minimum. This calculation was performed for a 7.60 x 15 tire and is shown in Fig. 18 as M_k/W, a function of e. The curve declines rapidly at first, then flattens off and finally rises again slightly. The design optimum for e is near the region where the rapid rate of change of M_k/W flattens out. Higher e values give only negligible decline in static steering torque and, in addition, exaggerate the highly undesirable effects of road shocks. Actual design usually takes a compromise between the two requirements.

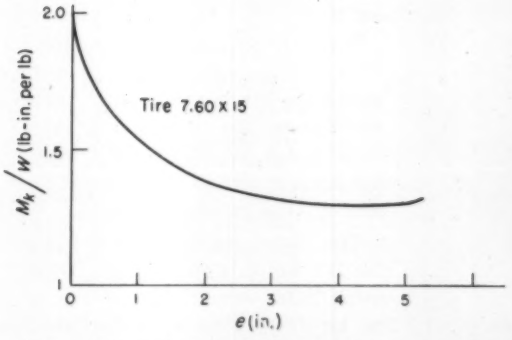


Fig. 18—Static-steering torque per unit radial load as a function of king-pin offset.

From the calculated torque M_k, the drag link force D necessary to produce this torque can be calculated from the geometrical relations of the steering linkages.

In the next part of this series, such calculations are illustrated for representative manual and power-steering linkage assemblies.

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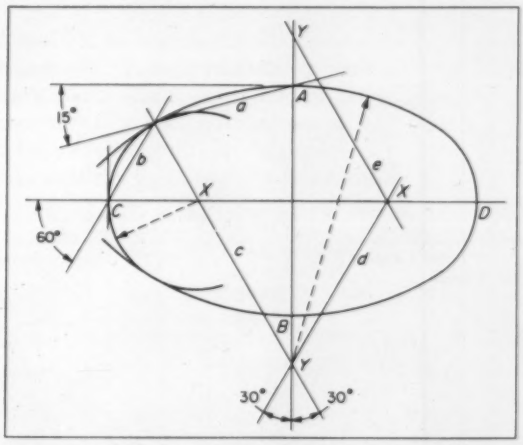
Tips and Techniques

Constructing Ellipses

An ellipse can be constructed quickly and easily by this method. Draw axes *AB* and *CD*. From point *A*, draw line *a* at an angle of 15 deg. from the horizontal. From point *C*, draw line *b* at an



angle of 60 deg from axis *CD*. Line *c* is drawn from the intersection of lines *a* and *b*, at an angle of 60 deg to the horizontal. Lines *a* and *e*, also at 60 deg from the horizontal axis, are drawn similarly. Points *X* and *Y* are the centers for swinging arcs. — RONALD MAREK, *Belock Instrument Co., College Point, N. Y.*

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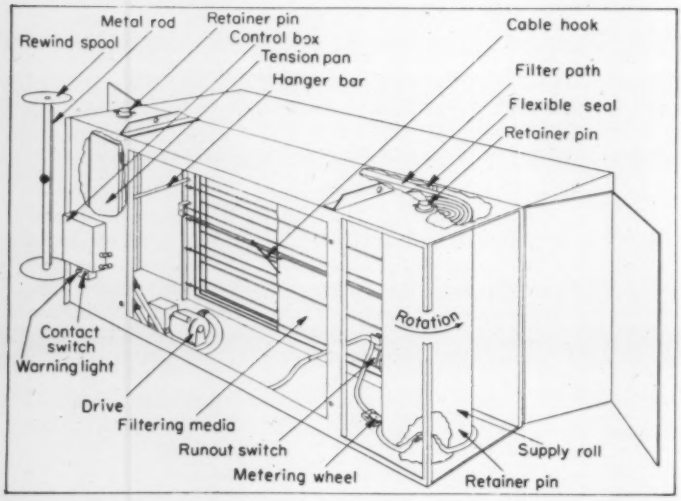
Flashbulb Reflector Is Integral with Camera

New Brownie Starflash camera made by Eastman Kodak is designed with a built-in flashbulb reflector and an eye-level view finder. The low-cost unit can be used, by means of an appropriate lever setting, to take black-and-white snapshots, color prints, or color transparencies from which color slides can be made.

Shutter is automatically cocked when film is advanced. Camera is thus provided with a double-exposure guard.

Filter Automatically Replaced in Air Cleaner

Filtering media in roll form is automatically moved through the air stream in Herman Nelson Roll-O-Vent air cleaners made by the American Air Filter Co., Inc. The Roll-O-Mat filter, which is composed of glass fibers bonded with thermosetting plastic, is removed from a tightly wound supply roll on one side of the unit and rewound on a rewind spool on the opposite side.



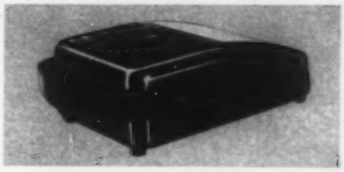
A preset electric timer automatically turns on the filtering media drive motor to operate for predetermined periods. The motor, operating through a gear reducer and chain drive, actuates the rewind spool and draws a small amount of new media into the air stream. Rate of filter use depends upon filter size and dust conditions. The amount of media fed into the air stream is measured by the metering wheel.

When the supply of filter material is about exhausted, a runout switch operates a warning light and disconnects the timer from the drive motor. At this point a manual contact switch is employed to run out the remaining media.

The timer operates only when the fan motor is operating to avoid using filter media when there is no air flow. This is accomplished by supplying electric power to the timer from the load side of the fan starter.

Three-Way Protection Guards Meter Against Overload

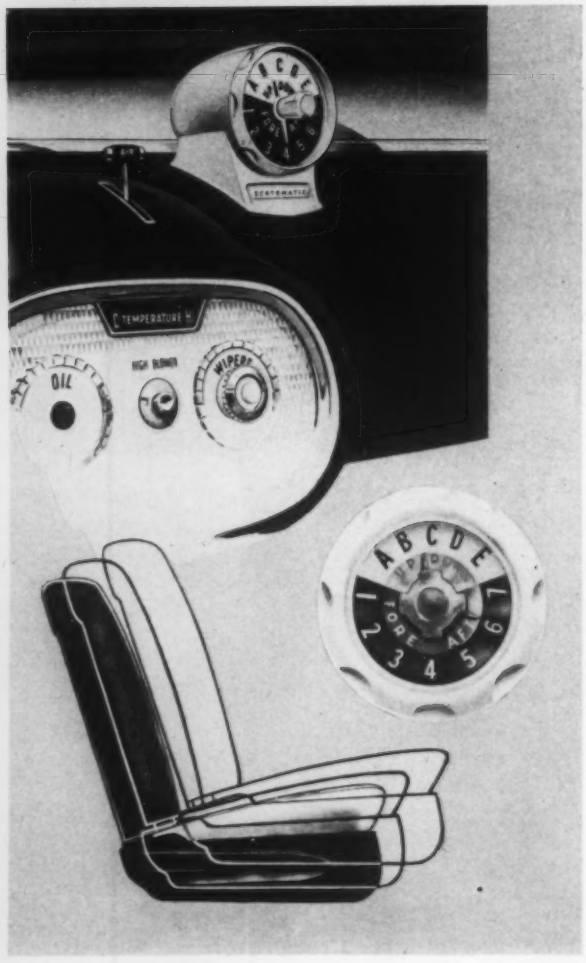
Curved face and slanted dial design improve readability in a new portable multimeter manufactured by Hickok Electrical Instrument Co. The meter employs a design technique that protects the entire internal circuit whenever a dangerous overload is applied. High voltage may be applied directly across any function, including ohms, without danger to the meter, resistors, shunts and other components. When an overload condition occurs, a relay disconnects the multimeter and automatically raises a reset button on the case. When overloads are too small to directly actuate the relay, auxiliary contacts, closed by the overdriving pointer, again open the protective circuit. Fused circuits provide additional protection on low-impedance scales.



Lightweight case, handle and knobs which are made of Durez phenolic plastic add to the multimeter's sleek appearance. All knobs are recessed to improve styling and protect knobs from damage.

Batteries, which power the unit, are housed in a special compartment that is easily accessible without removing the case. Batteries snap in and out with ease. No soldering is required.

Seat Position Is Dial Controlled



In 1957 Mercury cars equipped with Seat-O-Matic power seats, turning on the ignition automatically moves front seat to a predetermined position that is most comfortable for the driver. Each driver adjusts a seat-position control dial mounted on the instrument panel until the seat moves into the most suitable position; that is his "setting." Any one of five vertical positions and seven horizontal positions may be obtained. When the ignition key is turned off, the seat automatically moves to its rear-most position to allow easy exit and entrance.

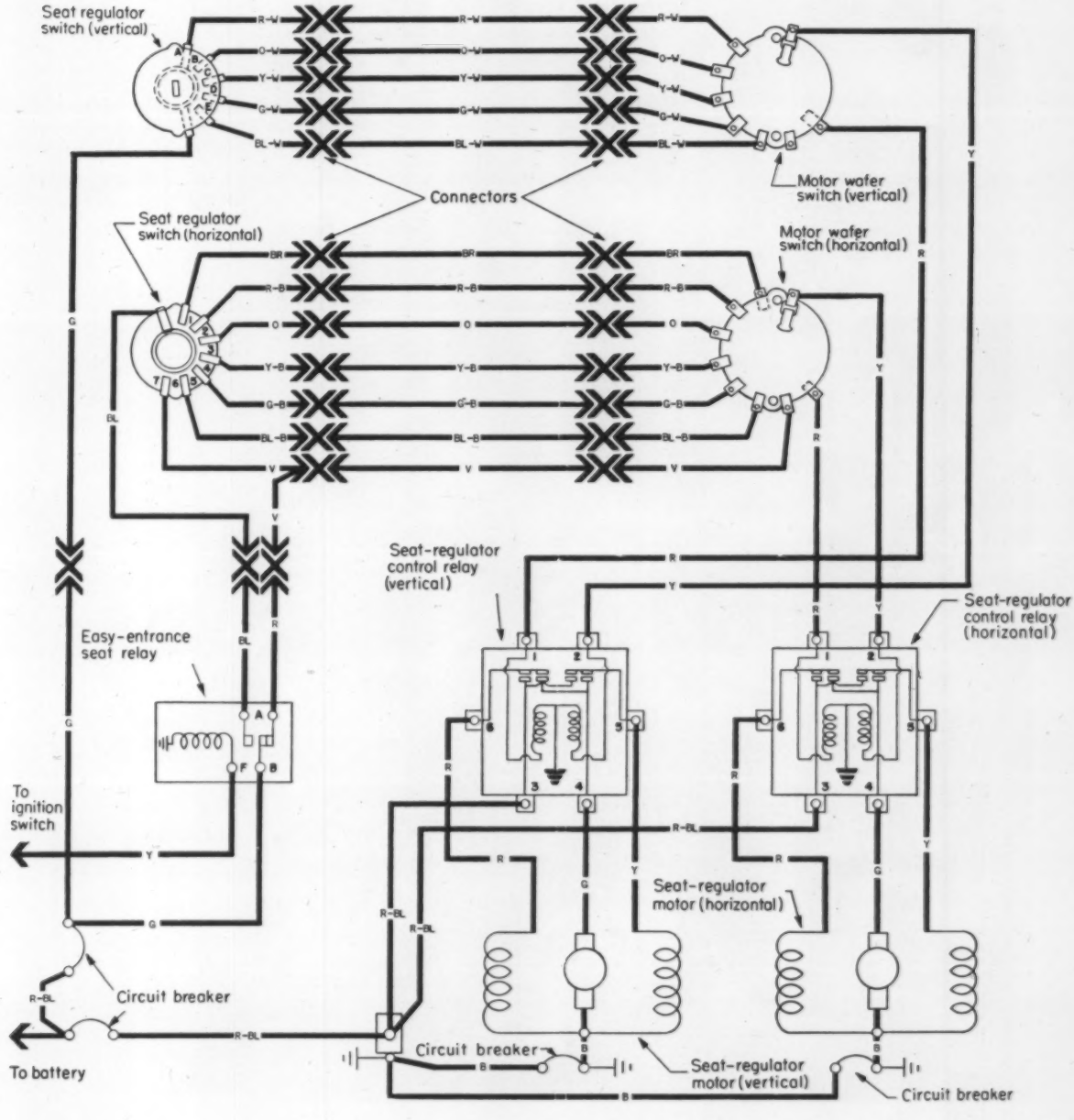
Control-circuit components consist of an easy-entrance seat relay, seat-position control dial, a vertical and a horizontal motor-seat-positioning switch, a vertical and a horizontal seat-regulator control relay, protective circuit breakers, and necessary wiring.

The easy-entrance seat relay allows the seat to return to the extreme rear position by completing

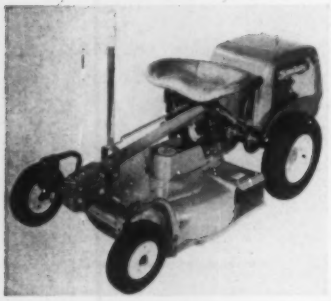
the circuit to the No. 7 terminal of the horizontal motor-seat-positioning switch when the ignition is off. With the ignition on, the seat relay is energized, completing circuit to seat-positioning switch.

The seat-position control dial turns a combination of two multiple-contact switches that are electrically connected to a horizontal and a vertical motor-seat-positioning switch. The latter two switches are wafer type units mounted on the rear of their respective motors and driven through gear reducers. The wafer switches establish the position of the seat by interrupting the seat-regulator control relay circuits when the seat reaches a preselected position.

The seat-regulator control relay completes the seat-regulator motor armature and field circuits as determined by the seat control dial and motor positioning switches.



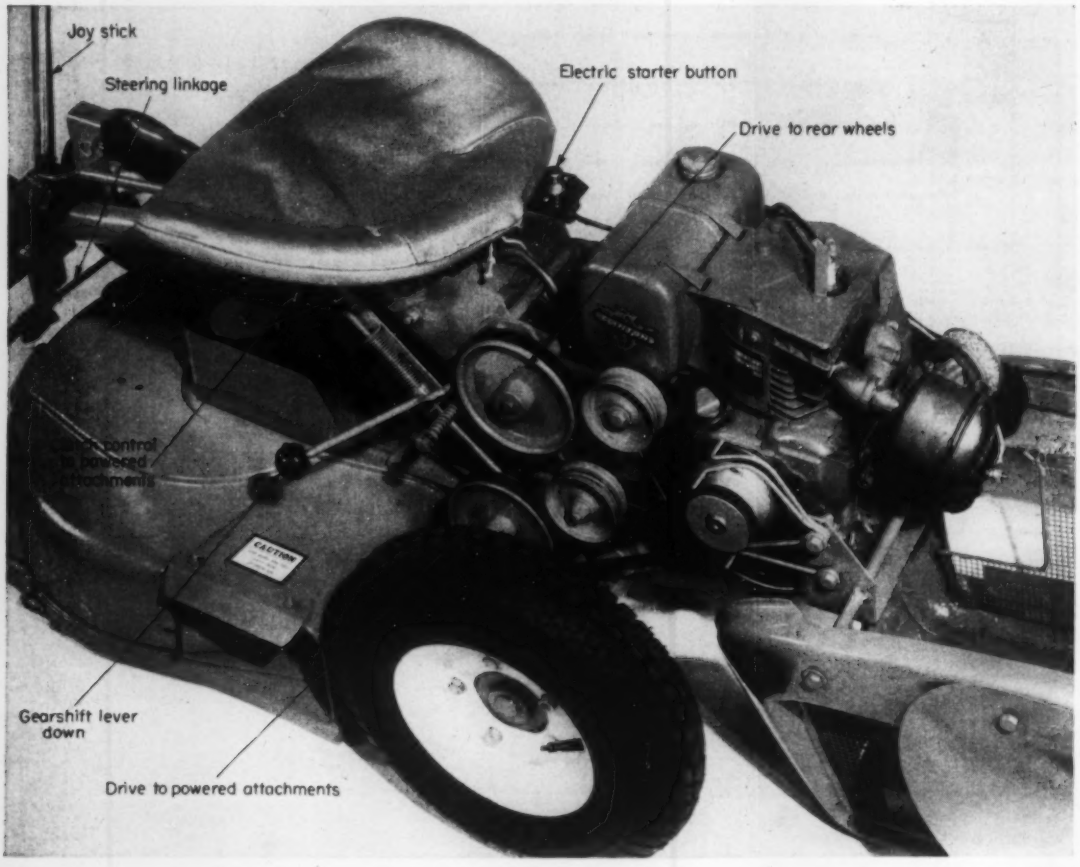
Joy Stick Steering and Clutching Control



In a riding type garden tractor made by the Simplicity Mfg. Co., a simple airplane type joy stick is used for both steering and clutching functions. Pulling the control-stick handle back engages the clutch, which connects the 3.6 hp engine to the rear wheels. Releasing the spring-loaded control handle automatically disengages the clutch, and the machine stops. Moving the stick right or left steers the front wheels on machine. Front-wheel spindles are spring loaded to permit practically automatic straightening out from turns.

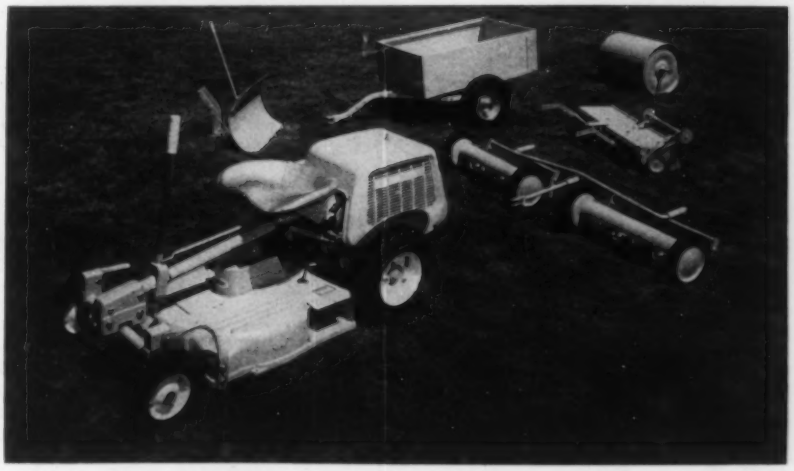
Center-point steering is easily achieved with centered-tube "chassis." Adjustable, double ball-joint suspension used on steering linkage to each front wheel provides strength, operating flexibility and ease of handling. Front axle pivots on center permitting either front wheel to raise or lower 8 in. from horizontal—a total travel of 16 in.

The gearshift lever is located to the driver's left under the seat. Pushing the gearshift lever down reverses the machine; this control also doubles as an emergency brake in the uppermost or lowest positions. Knob and linkage located further under the seat are used to clutch powered attachments.



Recoil starter handle on a nylon cable is easily accessible through a large opening in right side of the protective hood. Fully enclosed, moistureproof and dustproof ignition system and hot-spark magneto insure easy starting. Electric starting designs are also available. Button on top of hood shuts off engine. Throttle control is mounted below and in front of seat.

Gardening attachments designed for tractor include a 24-in. combination rotary mower and leaf mulcher, 30-in. reel type mower, two gang companion mowers for 59-in. width of cut, ½-ton trailer cart, 21½-in. roller, 30-in. wide grader and snow blade.



Methods of

Improving Servo-System

PART 2

- **Velocity Feedback**
- **Acceleration Feedback**
- **Transient-Velocity Feedback**

PROBLEMS faced in the first part of this article were: (1) How to stabilize systems which are unstable or exhibit poor relative-stability characteristics, and (2) How to improve system performance without violating stability requirements.

It was supposed that little could be done in the way of altering the characteristics of the basic components; the desired improvements were achieved by introducing special frequency-sensitive elements in the forward path of the loop. These elements can be placed anywhere in the forward path provided the complete system is linear, but usually they are put in the low-power end of the transmission to minimize requirements for extra power.

In this article it will be shown that similar results can be achieved by other methods. As a first example consider the simple system of Fig. 18*a* in which an amplifier-motor drive produces a torque T proportional to the error e. Then if the load is simply an inertia I, the loop transfer function is

$$\frac{\theta_o}{e}(s) = \frac{K}{Is^2} \qquad (28)$$

The system is apparently unstable.

A physical explanation is helped by plotting

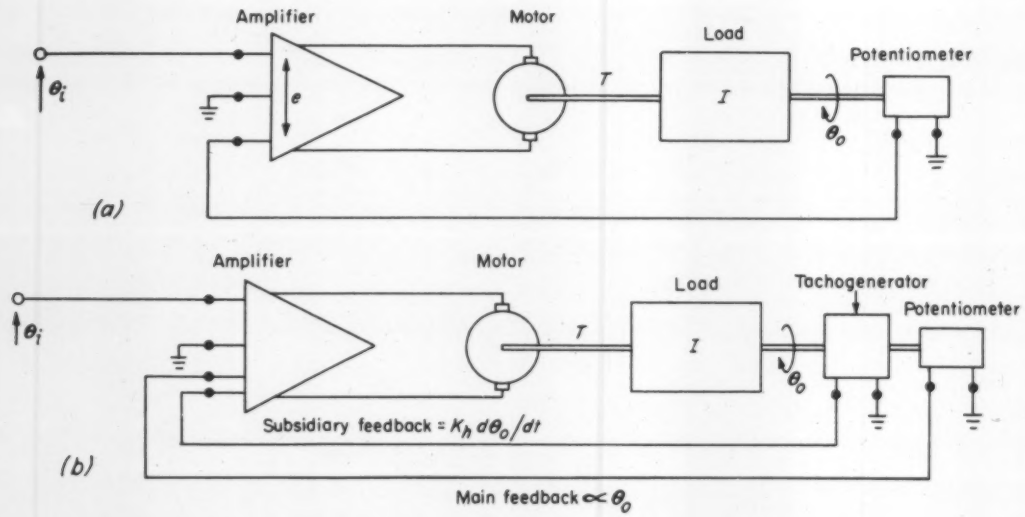


Fig. 18—Simple position-control servo. At *a*, the amplifier responds only to the error between input and output. The system is unstable since there is effectively no damping in the system. Stability is achieved at *b* by subtracting from amplifier input a voltage proportional to output velocity. Effect is same as that which would be produced by viscous damper on output shaft but without loss of power efficiency.

Performance

By J. M. Nightingale
Manchester, England

θ_o, $d\theta_o/dt$, $d^2\theta_o/dt^2$ and T to a common time scale, Fig. 19*a*, when the input θ_i is a unit step. In time interval 0 to t_1 torque T assists the output motion and the motor supplies power to the load. During t_1 to t_2, however, the motor torque opposes motion and power is returned to the motor. Gradually the output comes to rest but not before an error equal but opposite to the initial error has been built up. The process of correction then occurs repeatedly, with no better result each time. Fig. 19*b* shows variation of T with θ_o in interval 0 to t_2. Equal areas above and below the θ_o axis indicate that the transfer of energy in the two half-periods is equal. Had there been some energy dissipation

Nomenclature

A	= Cylinder piston area
e	= Error
e_1, etc.	= Signal voltages
$H(s)$	= Transfer function of subsidiary feedback path
I	= Inertia
K	= Loop scalar gain constant
K_a	= Gain constant
K_1, etc.	= Gain constants
m	= Mass
s	= Laplace operator
T	= Torque
t	= Time variable
$Y_c(s)$	= Overall transfer function
$Y_o(s)$	= Loop transfer function
θ_i	= Input
θ_o	= Output
λ_c	= Cylinder stiffness
λ_v	= Valve stiffness
ζ	= Damping coefficient of quadratic lag

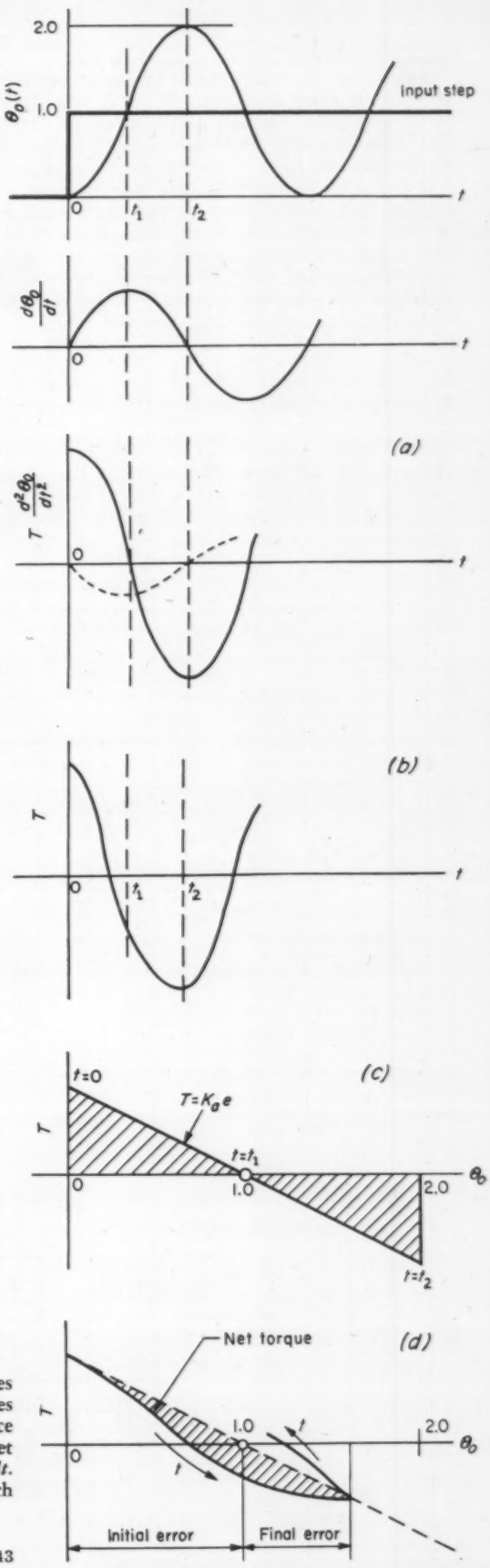


Fig. 19—Variation of output displacement, its derivatives and torque for a step-function input. At *a*, all quantities are cyclic and undamped. This is due to energy balance shown in torque-displacement curve at *c*. In *b*, the net torque contains a component proportional to $-d\theta_o/dt$. This results in a torque-displacement curve, *d*, in which there is an apparent dissipation of energy per cycle.

the system would ultimately come to rest.

Suppose now a component of torque proportional to $-d\theta_o/dt$ were applied to the load (see dotted curve, Fig. 19*a*). The net torque is shown in Fig. 19*c*. A decelerating torque now appears before the output reaches unity (input line). This suggests that the output speed will have been reduced sufficiently before crossover to reduce the amount of overswing. The torque-displacement curve, Fig. 19*d*, shows that compared with the previous torque line, shown dotted, the torque becomes zero before crossover at t_1 and the overswing is therefore less to balance the energies absorbed and returned by the load. The area shaded can be thought of as the energy dissipated by the component proportional to $-d\theta_o/dt$ although this is not necessarily the physical explanation.

A series of corrective swings will follow and in each case the final error will be smaller than the initial error. Ultimately the error will vanish, so that stability has been achieved.

How can this modification be realized physically? One way is to put a viscous damper on the output shaft and effectively reduce the motor torque by a component proportional to $d\theta_o/dt$. In this case the actual motor torque still follows the dotted curve shown in Fig. 19*d* and the shaded area really does represent energy dissipated in the damper. Since this energy must be supplied from the power drive, the efficiency of the system is reduced, perhaps seriously.

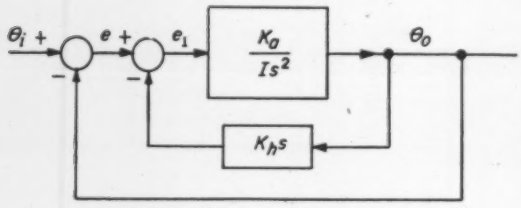


Fig. 20—Block diagram of system shown in Fig. 18*a*. Velocity feedback appears as an inner loop within the main loop of the system.

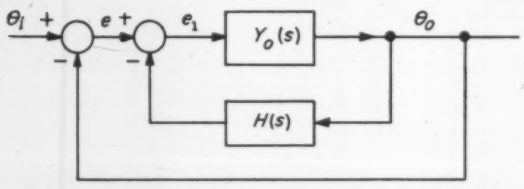


Fig. 21—Block diagram of general system with subsidiary feedback. It is possible to choose a form for $H(s)$ to meet the needs of the specific system in question.

Velocity Feedback: Suppose instead there is subtracted from the input to the amplifier a voltage proportional to output speed, obtained perhaps from a tachogenerator on the output shaft, Fig. 18*b*. The net input to the amplifier is now $e - (K_h d\theta_o/dt)$ so that the desired component is added to the torque produced. Since little power is consumed in driving the tachogenerator, efficiency is little impaired. The shaded area in Fig. 19*d* in this case represents a quantity of energy which the $K_h d\theta_o/dt$ component of signal now prevents the motor from delivering.

Fig. 20 shows a block diagram of the modified system. The loop transfer function is now

$$\frac{\theta_o}{e}(s) = \frac{\frac{1}{K_h}}{s\left(1 + \frac{sI}{K_a K_h}\right)} \qquad (29)$$

and the overall transfer function is therefore

$$\frac{\theta_o}{\theta_i}(s) = \frac{K_a}{Is^2 + K_a K_h s + K_a} \qquad (30)$$

The term $K_a K_h s$ thus insures stability. Note that the order of the system was two, Equation 28, but has now been reduced to one, Equation 29.

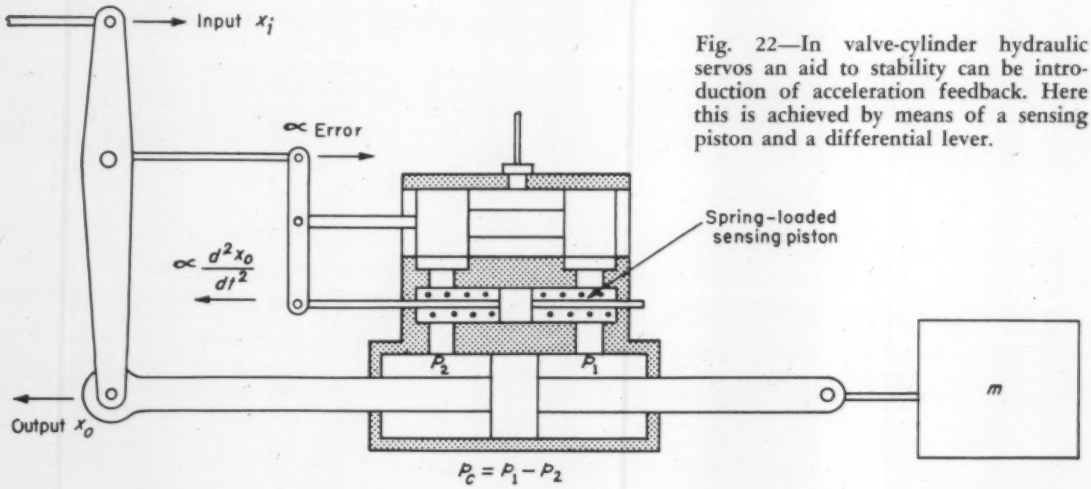


Fig. 22—In valve-cylinder hydraulic servos an aid to stability can be introduction of acceleration feedback. Here this is achieved by means of a sensing piston and a differential lever.

The principle just employed can be extended in a more general way. Thus the subsidiary feedback can involve a quite general function of the output. Fig. 21 shows a general representation. Loop transfer function of the original system is $Y_o(s)$, while $H(s)$ is a transfer function representing the characteristics of the elements in the subsidiary feedback path. Usually these elements are purely passive and so $H(s)$ will be the ratio of two polynomials, thus

$$H(s) = \frac{b_m s^m + \ldots + b_1 s + b_0}{a_n s^n + \ldots + a_1 s + a_0} \qquad (31)$$

Normally only simple functions are chosen, e.g. $Ts/(1 + Ts)$, $1/(1 + Ts)$, Ts^2, . . . , but there is no reason why $H(s)$ should not be tailored to suit the needs of the system in question.

The loop transfer function for the modified system can now be found from the inner-loop in Fig. 21. Thus

$$\frac{\theta_o}{e}(s) = \frac{Y_o(s)}{1 + Y_o(s)H(s)} \qquad (32)$$

and the overall transfer function becomes

$$\frac{\theta_o}{\theta_i}(s) = \frac{Y_o(s)}{1 + [1 + H(s)]Y_o(s)} \qquad (33)$$

The question of synthesizing $H(s)$ to suit particular systems will be taken up in a future article. Here only some well-tried applications to meet common deficiencies in servo systems will be discussed.

As a simple application, consider a system for which, Fig. 21, $Y_o(s) = K_1/s(1 + Ts)$ and for which $H(s) = K_2 s$. The overall transfer functions in the cases when the subsidiary feedback is omitted and included are, respectively,

$$\frac{\theta_o}{\theta_i}(s) = \frac{K_1}{Ts^2 + s + K_1} \qquad (34)$$

$$\frac{\theta_o}{\theta_i}(s) = \frac{K_1}{Ts^2 + (1 + K_2 T)s + K_1} \qquad (35)$$

In each case the denominator consists of a quadratic lag term. The relative stability of such systems is specified by the damping coefficient ζ which is, respectively, $1/2\sqrt{(K_1 T)}$ and $(1 + K_1 K_2/2\sqrt{(K_1 T)}$ in the two cases. Then for equal values of ζ (say $\zeta = 0.6$) in the two cases, it follows that the scalar gain constant is increased $(1 + K_1 K_2)$ times when the subsidiary feedback is employed. This means that for the same relative stability the bandwidth can be increased $(1 + K_1 K_2)$ times and the steady-state velocity error reduced by $1/(1 + K_1 K_2)$ times by employing the subsidiary feedback loop. Thus the overall accuracy and sensitivity can be greatly improved if $K_1 K_2 > 1$.

It is important to note, however, that merely putting the output-derivative feedback around the existing system reduces its scalar gain in the ratio $1/(1 + K_1 K_2)$. Hence to enjoy the advantages offered by increasing the gain constant, the gain of some adjustable element in the loop, for example an electronic amplifier, has to be increased $(1 + K_1 K_2)^2$ times. In position-control servos the use of output-derivative feedback is frequently called *velocity feedback*.

Acceleration Feedback: In some cases it is advantageous to use output acceleration rather than velocity-feedback. Difficulty here lies in obtaining a signal which is a true measure of the second derivative of output. One approximate means might be to use a tachogenerator whose output is passed through a differentiating circuit. An example in which approximate acceleration feedback is useful will now be discussed.

The loop transfer function for a valve-cylinder hydraulic servo was developed in Reference 10, Equation 16, when the output load is purely an inertia. Stability was found to depend on λ_v, the so-called valve stiffness. Suppose that no neutral leakage is provided so that effectively λ_v is infinite in the neutral position. Then the loop transfer function is

$$Y_o(s) = \frac{K_1}{s\left(1 + \frac{ms^2}{\lambda_c}\right)} \qquad (36)$$

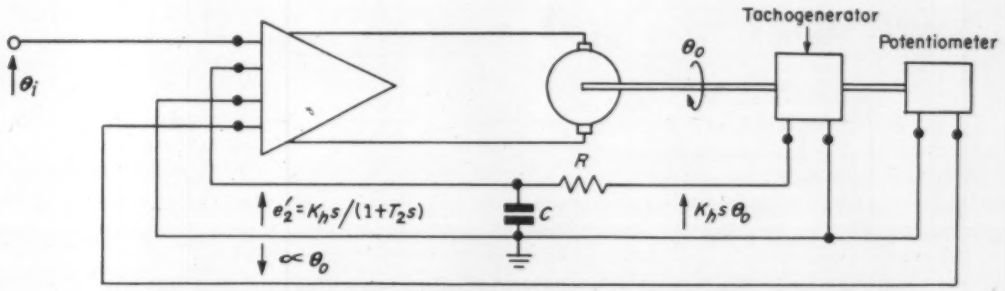


Fig. 23—The voltage from the tachogenerator is processed by *RC* network before entering amplifier. This produces characteristic known as transient-velocity feedback. By suitable selection of constants, zero velocity error can be achieved without endangering stability.

The overall transfer function is

$$Y_c(s) = \frac{K_1}{K + s + \frac{ms^3}{\lambda_c}} \qquad (37)$$

Equation 37 reveals immediately that the system is unstable, since there is no term in s^2 in the denominator (see Reference 3). Suppose now a subsidary feedback loop is employed in which $H(s) = K_2 s^2$, i.e., acceleration feedback. The loop and overall transfer functions now become, respectively,

$$Y_o(s) = \frac{K_1}{s\left(1 + K_1 K_2 s + \frac{ms^2}{\lambda_c}\right)} \qquad (38)$$

$$Y_c(s) = \frac{K_1}{\frac{ms^3}{\lambda_c} + K_1 K_2 s^2 + s + K_1} \qquad (39)$$

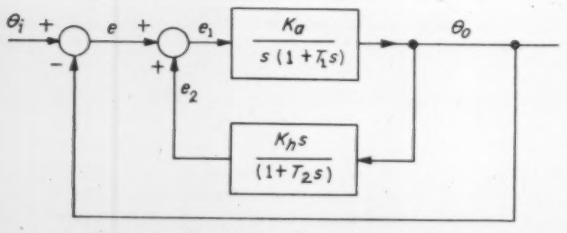


Fig. 24—Block diagram of system shown in Fig. 23. Note that, for inner loop, feedback is positive since incoming signals add at the differential.

Routh's criterion now reveals that the system can be stabilized if $K_2 > m/\lambda_c$.

Fig. 22 shows a practical way in which the acceleration signal can be obtained. In this case the output load itself depends on the output acceleration; hence, the differential cylinder pressure is given by $p_c = (m/A)d^2x_o/dt^2$. The small spring-loaded sensing piston produces a displacement roughly proportional to output acceleration and by means of a lever differential this displacement is subtracted from the input to the control valve. This achieves the desired result only if the output load is an inertia only. However, even if other components of load are present, this scheme can be a valuable one for stabilizing the system.

Transient-Velocity Feedback: The final example of the use of a subsidiary loop illustrates a somewhat different application. Fig. 23 shows an amplifier-motor drive whose transfer function, including load, is taken to be

$$\frac{\theta_o}{e_1}(s) = \frac{K_a}{s(1 + T_1 s)} \qquad (40)$$

where e_1 is the input to amplifier.

The amplifier receives as usual a signal dependent on error, but in this case it also receives an additive signal depending on the output speed. Thus the subsidiary loop here employs positive rather than negative feedback, Fig. 24. The component of voltage supplied to the amplifier by subsidiary feedback is given by the transfer function

$$\frac{e_2'}{\theta_o}(s) = \frac{K_h s}{1 + T_2 s} \qquad (41)$$

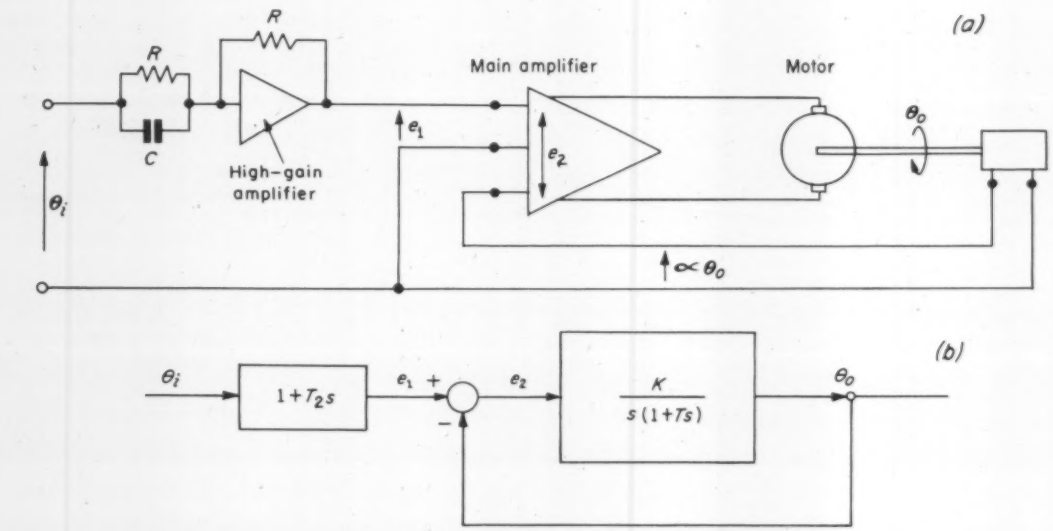


Fig. 25—Here input signal is processed before entering loop. By adding a term proportional to input derivative, results can be achieved which are similar to those obtained by use of transient-velocity feedback. Elements outside the loop have no effect on the stability of the loop itself. At *a*, a line diagram of the system is shown, while *b* is the corresponding block diagram.

where $T_2 = RC$. Such a component is often called a *transient-velocity feedback*. The modified loop transfer function now becomes

$$\frac{\theta_o}{e}(s) = \frac{K_a(1 + T_2 s)}{s[1 - K_a K_h + (T_1 + T_2)s + T_1 T_2 s^2]} \quad (42)$$

Now by making $K_a K_h = 1$ this reduces to

$$\frac{\theta_o}{e}(s) = \frac{\dfrac{K_a}{T_1 + T_2}}{s^2}\left[\frac{1 + T_2 s}{1 + \left(\dfrac{T_1 T_2}{T_1 + T_2}\right)s}\right] \quad (43)$$

Hence, the order of the servo has now been increased to two. This means that there will be zero velocity error provided the system is stable. The important thing to note is that phase advance has also been introduced, since time constant T_2 of the lead term in the numerator is greater than the time constant of the lag in the denominator.

As pointed out in Part 1, (Reference 12) this phase advance is very necessary if the system is to be stable. The overall transfer function is now

$$\frac{\theta_o}{\theta_i}(s) = \frac{K_a(1 + T_2 s)}{T_1 T_2 s^3 + (T_1 + T_2)s^2 + K_a T_2 + K_a} \quad (44)$$

Application of Routh's criterion shows that the system is still unconditionally stable, but for suitable relative stability characteristics, T_2 should be several times greater than T_1.

Other Methods: The examples outlined here, although typical of the approach to design improvement by subsidiary feedback, far from expend the total possibilities. It is hoped at a later date to give an outline of synthesis techniques whereby systems can be tailored to give specified performance.

Several other methods for altering system characteristics are known. One, possibly crude but effective where power demands are not severe, is to use viscous dampeners at the output or other suitable stations in the system. One such application was outlined briefly earlier in this article. Yet another approach is to attempt to achieve the modification outside the main loop. As an example consider the system shown in Fig. 25. Here the amplifier responds to a term proportional to the derivative of input signal as well as to the error. Effectively the input to the loop is given, Fig. 25*b*, by the transfer function

$$\frac{e_1}{\theta_i}(s) = 1 + T_2 s \quad (45)$$

The response of the system to amplifier input e_2 is given by

$$\frac{\theta_o}{e_2}(s) = \frac{K}{s(1 + T_1 s)} \quad (46)$$

The overall transfer function can be found from the block diagram, thus

$$\frac{\theta_o}{\theta_i}(s) = \frac{K(1 + T_2 s)}{T_1 s^2 + s + K} \quad (47)$$

From this the apparent loop transfer function can be found. It is

$$\frac{\theta_o}{e}(s) = \frac{K(1 + T_2 s)}{T_1 s^2 + (1 - KT_2)s} \quad (48)$$

If we make $KT_2 = 1$, this reduces to

$$\frac{\theta_o}{e}(s) = \frac{K(1 + T_2 s)}{T_1 s^2} \quad (49)$$

Notice that the system is now of second order, having zero velocity error. The denominator of the transfer function in Equation 47 shows that the system is stable. Thus results similar to those obtained by using transient-velocity feedback have been achieved. One practical danger is that any spurious signal, or noise, of high-frequency content mixed with input will be emphasized by differentiation.

Note too that the foregoing or similar methods cannot be used to stabilize the system if originally unstable, since no device outside the loop can affect the transmission characteristics of the closed-loop.

The next article in this group will discuss quantitative design of servo systems by frequency-response methods.

REFERENCES

This article is the thirteenth in a co-ordinated group by J. M. Nightingale on servo systems. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" ..... May 17, 1956
2. "Servo Mathematics" ..... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" ..... July 26, 1956
4. "Evaluating Servo System Performance—Part 2" ..... Aug. 9, 1956
5. "Analyzing Servo Systems" ..... Nov. 1, 1956
6. "Hydraulic Servo Components—Part 1" ..... Nov. 29, 1956
7. "Hydraulic Servo Components—Part 2" ..... Dec. 13, 1956
8. "Hydraulic Servo Components—Part 3" ..... Dec. 27, 1956
9. "Hydraulic Servos—Part 1" ..... Feb. 21, 1957
10. "Hydraulic Servos—Part 2" ..... Mar. 7, 1957
11. "Hydraulic Servos—Part 3" ..... Mar. 21, 1957
12. "Improving Servo System Performance—Part 1" ..... May 30, 1957

REPRINTS

Articles listed above by J. M. Nightingale are now available in reprint form. Articles 1 to 5 are contained in Volume 1 (32 pages) and articles 6 to 11 in Volume 2 (32 pages) of "Hydraulic Servo Fundamentals." The volumes are available at $1.00 each from Readers Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Tips and Techniques

Rubber Stamps

Rubber stamps for frequently used notations or personal signatures can be carved from a common rubber eraser in a few minutes. The lettering desired is penciled on a piece of paper with a soft pencil. Turn the paper over and transfer the carbon from paper to eraser by rubbing. Use a sharp knife to cut away all rubber where there is no pencil carbon on the surface. The time involved is about ten minutes for a personalized signature.—E. S. SOHL, *General Electric Co., Naval Ordnance Dept., Pittsfield, Mass.*

Supplement

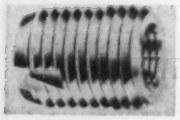
Design Guide to Industrial

Detailed information on 191 fastener types in seven basic categories appeared in "Design Guide to Industrial Fasteners," MACHINE DESIGN, August 23, 1956.

This first supplement presents 22 additional fasteners. They include those not covered in the original Guide as well as types developed since its publication.

INSERTS

Inserto



Form: Internally and externally threaded bushing. Internal threads accommodate standard screw sizes and are broached the entire length of the insert to form a hexagon socket for insertion of driving tool. External threads are self-tapping for driving into drilled or cored hole; interference fit produced by thread-cutting action and truncated thread design locks insert securely in place.

Design Features: Eliminates need for separate tapping operation. Will fit into Class 3 tapped hole. Built-in socket design simplifies assembly and disassembly. Provides strong working thread surface which resists high torque and tension loads.

Materials: Case-hardened cold-rolled steel, and heat-treated alloy steel.

Sizes: No. 4 to ½-in., Coarse and Fine internal threads, Class 3.

Source: Rosan Inc., Newport Beach, Calif.

Molly Screw Anchor

Form: Single-unit, blind anchor nut consisting of metal sleeve with threaded and flanged ends separated by a slotted expander section. Sleeve is pressed into drilled hole with flange against part surface and screw is inserted to engage threaded end. As screw is tightened, slotted section expands and draws in tightly against back of part to form blind head, locking assembly firmly in place.

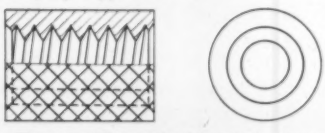
Design Features: Provides a permanent thread anchor in blind or open locations for sheet metals or soft materials where tapping is impractical or undesirable. Spider shape of blind head reinforces section around hole.

Materials: Aluminum-killed steel.

Sizes: No. 6-32, No. 10-24 and ¼-20 screw threads. Grip lengths from 1/16 to 1¾ in. Body styles include standard flange head and utility plug design with neoprene gasket under large head for sealing or shock absorption.

Source: Molly Corp., Reading, Pa.

Yardley Type B Insert



Form: Through-threaded insert with knurled external surface. Insert is designed to be molded into plastic, rubber and ceramic materials. Holes are reamed to close tolerances after tapping to facilitate placing inserts on locating pins in the dies. External knurls hold insert firmly in place.

Design Features: Provides strong permanent threaded hole in materials where tapping is impractical or undesirable. Both ends of insert are countersunk for use at either end and for easy handling. Coarse knurls are provided on external surface to develop maximum holding power.

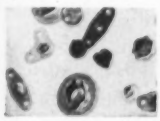
Materials: Aluminum.

Sizes: No. 4-40 to ¼-28 internal threads.

Source: Yardley Precision Products Co., Yardley, Pa.

NUTS

Con-Torq Nut



Form: One-piece, all-metal prevailing torque locknut. Body of nut is in form of a threaded barrel with two longitudinal crimped ribs and a flanged base. Barrel is slightly tapered inward at top and spreads apart when engaged with screw thread to provide secure spring-locking action.

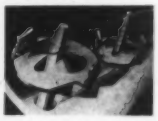
Design Features: Reusable. Provides a lightweight, secure seated locknut, adjusting nut or stop nut. Locking action withstands vibration or changing atmospheric conditions. Adaptable to high-speed assembly operations. Can be assembled with pliers or hex wrench.

Materials: Spring steel.

Sizes: No. 2 to ⅜-in.; Coarse and Fine threads. Body styles include several flange designs.

Source: Con-Torq Inc., Subsidiary of North & Judd Mfg. Co., New Britain, Conn.

Dot T.C.F. Nut



Form: One-piece, all-metal thread-cutting, prevailing-torque locknut. Nut body is in form of sheet-metal disk with two thread-cutting prongs at center opening

Fasteners

and two projecting lugs on the outer edge. Nut cuts its own mating thread when driven onto unthreaded stud or rod members by means of the projecting lugs. Interference fit produced by thread-cutting action holds nut firmly in position.

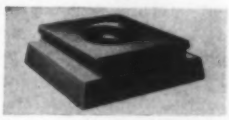
Design Features: Reusable. Provides low-cost locking fastener for lightly loaded unthreaded studs, rods and other similar members. Resists loosening by vibration. Provides spring-takeup action and pulls up tight without backup on flat or contoured surfaces. Particularly suited for holding die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces.

Materials: Steel.

Sizes: ⅛ and 3/16-in. nominal stud diameters. Body styles include sealing and nonsealing types.

Source: United-Carr Fastener Co., Cambridge, Mass.

Fabristeel Pierce Nut



Form: One-piece, all-metal, self-piercing clinch nut. Nut has rectangular head and pilot-type projection separated by undercut section. Hardened face of pilot pierces its own hole when pressed against metal part surface. Impact against die snaps and cold works metal into undercut to lock nut securely in place.

Design Features: Readily adaptable to high-speed continuous or batch-type production assembly methods. Eliminates need for separate hole punching operation. Can be installed on metal sections from 0.025 to 0.125-in. thick. Provides a permanently attached nut for assembly of threaded fasteners in blind or open locations. Offers high resistance to vibration and tension or shear loads. Can be used as a conventional clinch nut on parts with prepared holes.

Materials: Work-hardened steel body with piercing surface of over Rockwell 100 B hardness.

Sizes: No. 6 to ⅜-in.; Coarse and Fine threads.

Source: Fabristeel Products Inc., Detroit.

Grippit

Form: One-piece, all-plastic, self-retaining locknut in form of unthreaded sleeve with flange head. Nut is snapped into square hole with flange against part surface and tapping screw is driven into sleeve. As screw is tightened, counterbored section of sleeve is drawn in tightly against back of part to form rigid locking collar.

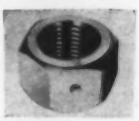
Design Features: Provides a low-cost locking screw receptacle for blind or open locations in sheet metal and thin sections. Locking action is resistant to vibration and shock. Adaptable to high-speed production assembly operations. Prevents chipping and crazing of enamel surfaces during assembly. Is electrically nonconductive.

Materials: Nylon.

Sizes: No. 8 and No. 10 tapping screw threads.

Source: Tru-Lock Fasteners Inc., Woodbury, Conn.

M-F Two-Way Locknut



Form: One-piece, all-metal, prevailing-torque locknut. Center portion of nut body is compressed so that center threads are elliptical while ends remain circular. Spring action of distorted section develops high radial locking force on threads of bolt.

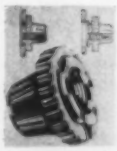
Design Features: Reusable. Provides continuing locking grip when center section is engaged. Nut is double chamfered and can be threaded from either end, facilitating automatic feeding and assembly methods. Can be used as an adjusting nut or stop nut. Locking action is maintained when nut is flush with bolt end or when nut threads are not fully engaged.

Materials: Low-carbon and heat-treated steel.

Sizes: No. 10 to ¾-in.; Coarse and Fine threads. Body styles include finished and heavy series hex in full and jam thicknesses.

Source: MacLean-Fogg Lock Nut Co., Chicago.

Press-Nut



Form: One-piece, all-metal, self-clinching nut. Nut body has a large serrated flange separating a small plain flange at one end and a slotted and tapered section at the other. Small flange is pressed or driven into prepared hole, seating face of serrated flange against part surface. Cold flow of material into space between flanges locks nut in place while teeth of serrated flange broach themselves into the part surface to prevent rotation.

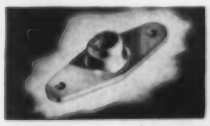
Design Features: Provides a strong flush-mounted tapped hole in sheet metal or plate members. Suitable for material thicknesses of 0.020 in. and greater. Can be assembled from one side in blind locations. Locking action resists high torque and pull-out loads.

Materials: Stainless steel and Ledloy.

Sizes: No. 2 to ¼-in.; Coarse and Fine threads. Body styles include selflocking and nonlocking internal threads.

Source: Rosan Inc., Newport Beach, Calif.

Sol-A-Nut



Form: One-piece, all-metal, prevailing-torque locknut. Body of nut is in form of threaded sleeve with

flange base. Upper threads of sleeve are deformed into oval shape to develop locking action.

Design Features: Reusable. Provides a secure, anchored locknut or stopnut. Provides high strength-weight ratio. Resists heat and corrosion.

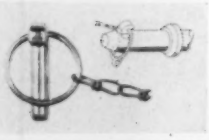
Materials: Corrosion-resistant stainless steel.

Sizes: No. 10-32 and ¼-28. Body styles include corner, plain and other flange designs for attachment by spot welding or riveting.

Source: Monadnock Mills, Subsidiary of United-Carr Fastener Corp., San Leandro, Calif.

PINS

Klik-Pin



Form: Quick-release locking pin assembly consisting of forged pin with ring mounted on head end. Pin is inserted in prepared hole in shaft or similar member, and ring is snapped over end of shaft to lock pin in place.

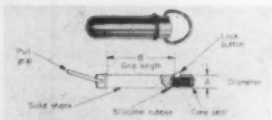
Design Features: Provides positive pin attachment with easy removal. Solid pin construction develops full shear strength of pin material. Rings are wound so that direction of spiral keeps them firmly closed when folded down against the pin. Requires no special assembly tools. Design of mounting holes for ends of rings assures good pivotal bearing and assists snap action of rings.

Materials: Pin is heat-treated high-carbon steel; ring is tempered steel.

Sizes: ¼ and 7/16-in. pin diameters; two snap ring sizes.

Source: Danuser Machine Co., Fulton. Mo.

WE-Pins



Form: Solid-shank, quick-release locking pin assembly containing rubber core and lock button. Lock button projects from surface of pin until sufficient force is applied in assembly or removal to depress button against spring action of rubber, releasing pin for movement.

Design Features: Reusable. Provides positive attachment with easy removal. Pull-out loads range from 10 to 25 lb, depending on pin size, to prevent accidental release due to vibration. Solid pin shank develops high shear strength varying from 3600 (¼-in.) to 58,000 lb (1 in.). Can be used as shear, lock, hinge or clevis pin. Locking mechanism resists vibration, corrosion and temperature variations.

Materials: Pin is stainless steel or chrome-moly steel. Core is silicone rubber composition.

Sizes: ¼ to 1 in. pin diameters. Grip lengths from ½ to 4 in. Pin styles include several pull-grip designs as well as dual lock-buttons in the larger diameters.

Source: Waldick Engineering Co., Garden City, N. Y.

RETAINING RINGS

Industrial Retaining Rings

Form: Stamped metal retaining rings. Rings are mounted in annular groove in shaft or housing bore.

Design Features: Provides low-cost shoulder for locking and positioning components on shafts and in housing bores. Designed to maintain circularity and constant gripping pressure in mounting groove. Can be reused without loss of resiliency. Open-type external rings for radial mounting on shafts can be adapted to high-production assembly techniques.

Materials: Carbon spring steel, stainless steel, phosphor bronze and beryllium copper.

Sizes: 0.040 to 2¼ in. nominal shaft diamteers; 0.250 to 2 1/16 in. nominal bore diameters.

Source: Industrial Retaining Ring Co., Irvington, N. J.

RIVETS

Daisy Rivet

Form: Two-piece tubular blind rivet consisting of preassembled sleeve and pin. In driving operation, sleeve is split by head of pin to form five "petal" segments on blind side. Spring action of spreading segments draws assembly pieces together and sleeve is cold swaged into locking grooves in pin at point of maximum clamp tension. Tail of pin breaks off automatically when rivet is completely driven.

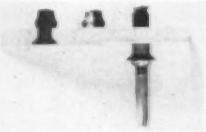
Design Features: Broad bearing area of blind head provides high resistance to tear-out or pull-through. Positive locking action holds pin securely in place. Provides high pull-together force. Particularly suited to high-speed assembly operations in blind or open locations.

Materials: Aluminum.

Sizes: ¼-in. nominal diameter. Various grip lengths.

Source: Huck Mfg. Co., Detroit, Mich.

Tau Bolt



Form: Four-piece tubular blind rivet consisting of preassembled expansion sleeve, filler sleeve, pin and locking collar. In driving operation, filler sleeve is forced between pin and expansion sleeve and into contact with shoulder near head on pin. Continued driving causes expansion sleeve to upset and form blind head. Locking collar on driving side is then cold swaged into keystone-type locking groove between pin and filler sleeve. Tail of pin breaks off automatically at predetermined tensile preload.

Design Features: Develops high shear and tensile strengths. Provides high tensile preload; installed force is double the rated strength. Has good assembly pull-together action. Flush pin-break eliminates need for trimming operation. Close-tolerance shank permits driving in interference fit holes. Can be readily adapted to high-speed assembly operations in blind or open locations.

Materials: Expansion sleeve is austenitic stainless steel; locking collar is mild steel, and filler sleeve and pin are heat-treated alloy steel.

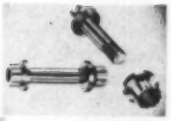
Sizes: ¼-in. nominal diameter. Various grip lengths. Head styles include countersunk or brazier.

Source: Huck Mfg. Co., Detroit, Mich.

SCREWS, BOLTS, STUDS

Hi Psi Bolt

Form: High-strength, 12-point external-wrenching locking bolt assembly. Bolt has special thread in



which root radius is increased 30 per cent to reduce stress concentration. Nut employs standard threads and has slotted collar with segments turned inward to produce secure prevailing-torque locking action.

Design Features: Reusable. Bolt assembly can develop tensile strength of from 220,000 to 240,000 psi and minimum shear strength of 130,000 psi; typical fatigue strengths possible, based on 8 million load cycles, include 76,000 psi for ½-in., 82,000 psi for ⅜-in. size. External wrenching, 12-point design of bolt head and nut facilitates extreme tightening to develop high preloads. Locking action of nut resists severe vibration. Nut and bolt head have increased bearing area on face to permit application in softer metals without excessive compression of the materials. Nut will withstand torque sufficient to break bolt. Bolt assembly provides high-strength weight ratio and was designed primarily for use where torquing to a high preload is required.

Materials: Alloy Steel.

Sizes: ¼ to 1½ in., UNF Modified thread, Class 3.

Source: Aircraft Products Div., Standard Pressed Steel Co., Jenkintown, Pa.

Long-Lok Screw

Form: Single-unit, prevailing-torque type self-locking screw. Plastic or metallic insert mounted in axial groove in threaded surface wedges screw threads against mating threads to develop firm locking grip.

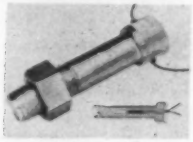
Design Features: Reusable. Can be used as an adjusting device. Locking action resists loosening effect of vibration. Can be readily adapted for low, medium or high temperature conditions by varying insert material. Insert serves as a seal to prevent leakage of fluid under pressure along threads.

Materials: Screw body is steel, brass or aluminum; insert is Plaskon, Kel-F, stainless steel or copper.

Sizes: No. 0 to ½-in. nominal diameters; Coarse and Fine threads. Various lengths. Body styles include all standard head types and driving recesses.

Source: Long-Lok Corp., Santa Monica, Calif.

Pic Load-Sensitive Screw



Form: Standard headed and threaded capscrew, or bolt, with special resistance-type strain gage potted axially at center of shank. Tension or compression of fastener is sensed by strain gage and transmitted to a calibrated potentiometer, permitting direct measurement of actual working loads.

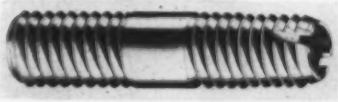
Design Features: Provides accurate (±1 per cent) measurement of actual tension or compression loads on bolt at any time during assembly or while in service. Permits dynamic measurements as well as periodic inspection tests. Can be used to equalize load distribution in multiple bolt arrangements, to avoid excessive tightening loads, to assure proper loading in highly stressed fasteners, or to serve as a load transducer for control or protection of machinery. Standard maximum operating temperature is 180 F.

Materials: Steel.

Sizes: ⅜ to 1 in. nominal diameters; Coarse and Fine threads. Lengths from 1¾ to 8 in. Body styles include hex and socket-head cap screws.

Source: Polyphase Instrument Co., Bryn Mawr, Pa.

Rosan Self-Tapping Stud



Form: Self-tapping, self-locking, size-on-size tap-end type stud. Tap-end thread has two thread-cutting slots and cuts its own mating thread as stud is driven into drilled hole. Threads beyond self-tapping portion produce an interference fit to lock driven stud securely in place.

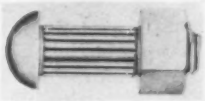
Design Features: Eliminates need for separate tapping operation. Will fit into standard tapped holes, Class 3. Can be installed with standard power tools in plastic, aluminum, magnesium and some low carbon steels and cast irons. Adaptable to high-speed assembly methods. Produces standard Class 3 thread in tapping operation.

Materials: Heat-treated alloy steel.

Sizes: No. 6 to ½-in. nominal diameters; Coarse and Fine threads, Class 3A.

Source: Rosan Inc., Newport Beach, Calif.

Structural Rib Bolt



Form: All-metal, prevailing-torque type locking bolt assembly. Bolt consists of standard rivet head and shank which is axially ribbed at upper end and has standard thread to receive mating prevailing-torque locknut. Bolt is driven into prepared hole, causing triangular-shaped ribs to deform in a body-bound fit that locks bolt securely in place. Nut is then applied and wrenched tight.

Design Features: Develops high-force locking grip. Nut is reusable. Provides higher shear and bearing strength than equivalent power-driven rivets. Bolt is easily removed without damage to edges of hole. Can be assembled with hand hammer and wrench. Used in rugged, heavy-duty assemblies or structures where stress, shock or vibration conditions are unusually severe.

Materials: Bolt is carbon manganese steel with minimum tensile strength of 70,000 psi; nut is open-hearth carbon steel with chrome vanadium steel locking pin.

Sizes: ⅜ to 1 in. nominal diameter; NC threads; Class 2. Lengths from 15/16 to 5⅜ in. Head styles include standard American Boiler Makers' Association button and countersunk.

Source: Automatic Nut Co. Inc., Lebanon, Pa.

Torq-Set

Form: High-strength, flat-head machine-bolt with forged internal driving socket of nonsymmetrical form. Bolt is tightened with conventional manual or power-operated driving tools using a special high-strength bit.

Design Features: Permits devel-

opment of extreme tightening torques. Provides high impact resistance. Can be adapted to high-speed assembly methods. Driving socket design simplifies tooling requirements and permits easy disassembly. Used primarily where a high preload is required.

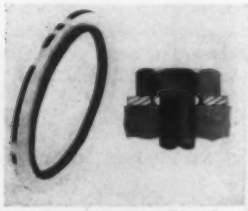
Materials: Alloy steel.

Sizes: No. 4 to ⅝-in. nominal diameters; Coarse and Fine threads. Various lengths.

Source: American Screw Co., Willimantic, Conn.

WASHERS

Dyna-Seal



Form: One-piece washer unit consisting of an inner flared rubber seal ring bonded to an outer confining steel washer. Projecting portion of rubber seal is compressed when fastened, causing inner flared edge to form a convex sealing surface opposing internal fluid pressure forces.

Design Features: Reusable. Provides a leakproof seal against gases and fluids under bolt heads, rivets, flanges and fittings. Sealing action is assisted by pressure forces. Resilient rubber ring provides a lock-washer action that resists vibration. Can withstand steady or pulsating pressures up to 10,000 psi without losing effectiveness of seal. One-piece washer design simplifies mounting problems and facilitates assembly operations. Temperature service range is 250 to −65 F. Gives maximum bearing surface under head of bolt or rivet.

Materials: Washer is steel; inner seal ring is oil-resistant synthetic rubber compound.

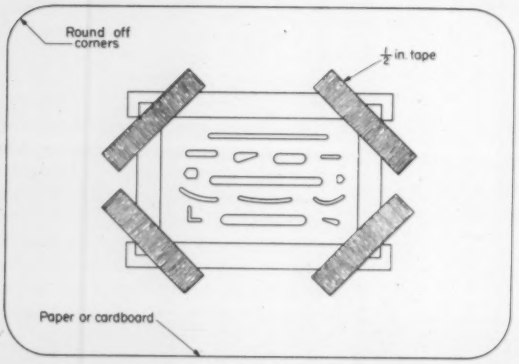
Sizes: 0.125 to 1.250 in. maximum bolt OD. Washer OD from 0.315 to 2.016 in.; thickness from 0.041 to 0.134-in.

Source: Precision Rubber Products Corp., Dayton, O.

Tips and Techniques

Keeping Erasing Shield Handy

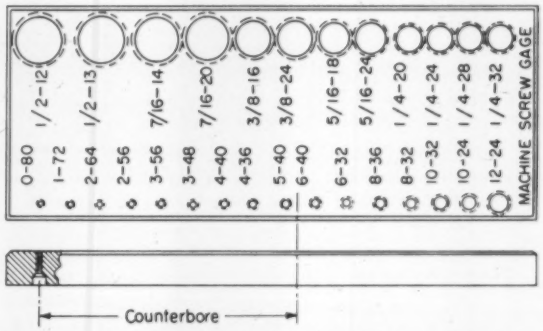
An erasing shield can be made easier to find and easier to handle by taping the shield into the center of a sheet of 8½ by 11 in. paper or



cardboard. When torn or soiled the paper is easily replaced. The sheet also serves to keep drawings clean under the hand when lettering.—M. MIGATZ, *Brach Mfg. Co., Newark, N. J.*

Screw-Thread Gage

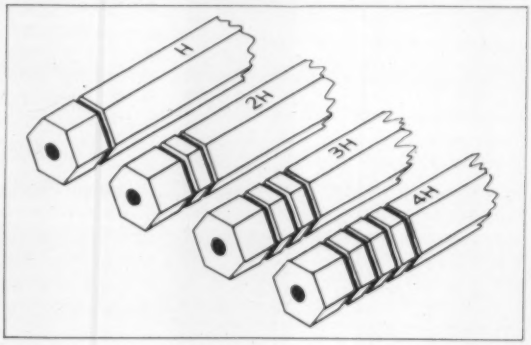
A simple thread gage can be made to determine both the size and pitch of commonly used screws. The gage will be found very useful for visualizing fastener sizes or identifying screws at hand. All the common sizes can be drilled and tapped in a plate 2¼ by 5½ in. and about ⅜-in. thick. The screw holes are drilled and tapped. To simplify tapping the No. 0 through No. 5 holes, these holes



should be counterbored from the back.—HAROLD BLYE, *New York.*

Identifying Pencils

Pencil-lead hardness can be determined at a glance if the pencils are notched to indicate the grade. Notching is done on three or six sides of the pencils.—PHILIP E. MCCAFFERTY, *Stanwood, Iowa.*



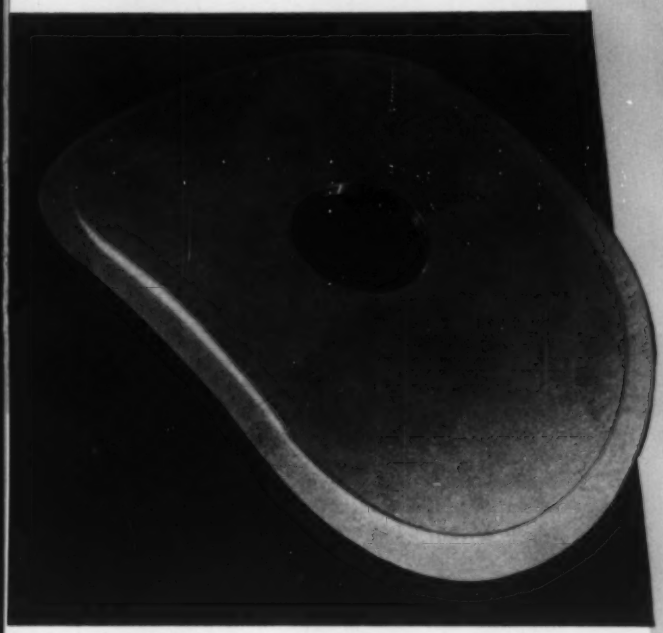
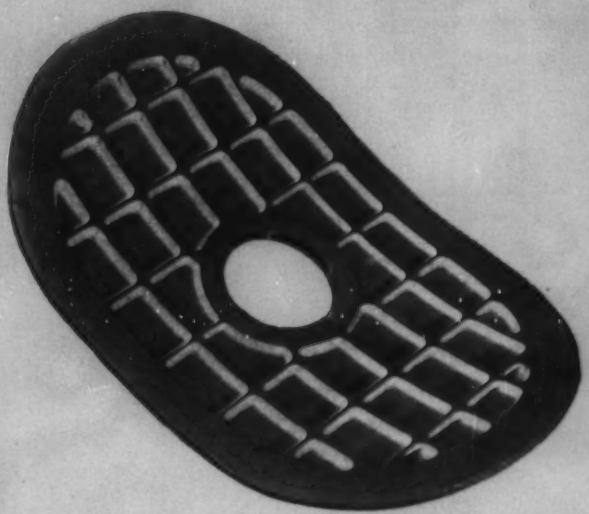


Fig. 1—Aircraft door was changed from aluminum casting to chemically milled part to save weight. Part is ½-in. thick plate, roll formed before milling. Web thickness after milling is 0.150-in. Cost is approximately same as machined casting.



Designing for

Chemical Milling

By R. W. Beckim
Production Design Engineer
and H. H. Muller
Process Engineer
Northrop Aircraft Inc.
Hawthorne, Calif.

CHEMICAL milling is a method of metal removal by chemical means rather than by conventional machining operations. The process was developed in the aircraft industry for the removal of metal on parts or under conditions that were impractical for conventional processes. Chemical milling has been used on alloys of aluminum, magnesium, stainless steel and titanium; but only aluminum and magnesium are being chemically milled on a production basis.

The Process

If all surfaces of a part are not to be subjected to chemical milling, masking must be applied to those surfaces where metal is not removed. To insure adherence of the masking compound, the part is first carefully cleaned. After masking, the parts are immersed in the etching solution. Metal is removed at a constant rate from all exposed surfaces. The rate of metal removal is approximately 0.001-in. per minute, varying with the alloy and the etchant concentration. When

Consider Chemical Milling When . . .

1. Curved surfaces must be reduced in thickness.
2. Large, shallow areas are involved.
3. Web thickness must be reduced to a degree impractical to hold for machining.
4. A number of small parts can be made as a unit from one sheet and cut apart later.
5. The area to be reduced has an intricate outline.
6. Machining of large sheets might cause warpage.
7. Parts are too large for machine-tool tables.
8. Low production does not warrant machining fixtures or templates.
9. No other heavy machining is required on part.
10. Fillet radii do not have close tolerances or are not less than depth of cut.
11. Internal areas must be enlarged.
12. Masking of areas not to be etched can be done economically.
13. Material is homogeneous and has a fine, uniform grain structure.

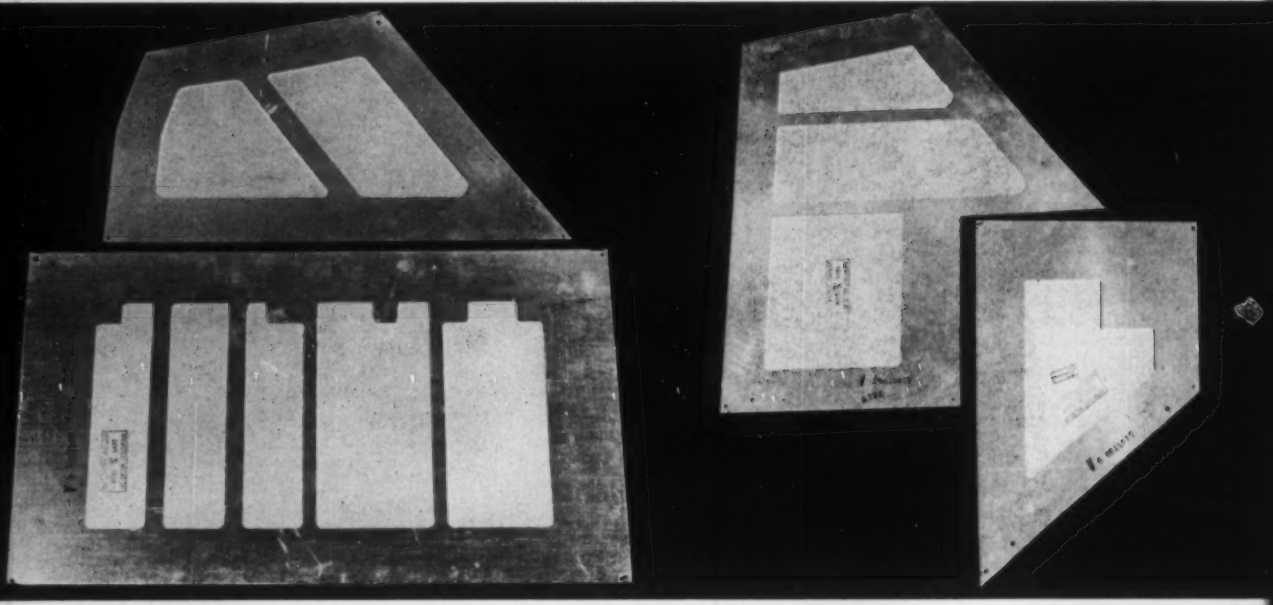


Fig. 2—Above—Access doors are contoured slightly before chemical milling. Process is applied to advantage on such parts, since remaining web thickness is insufficient for practical machining. Parts can be chemically milled in large batches economically.

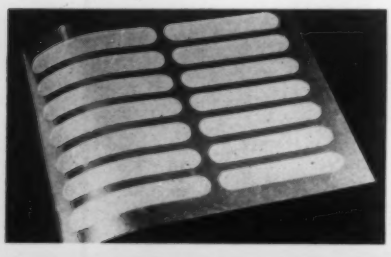
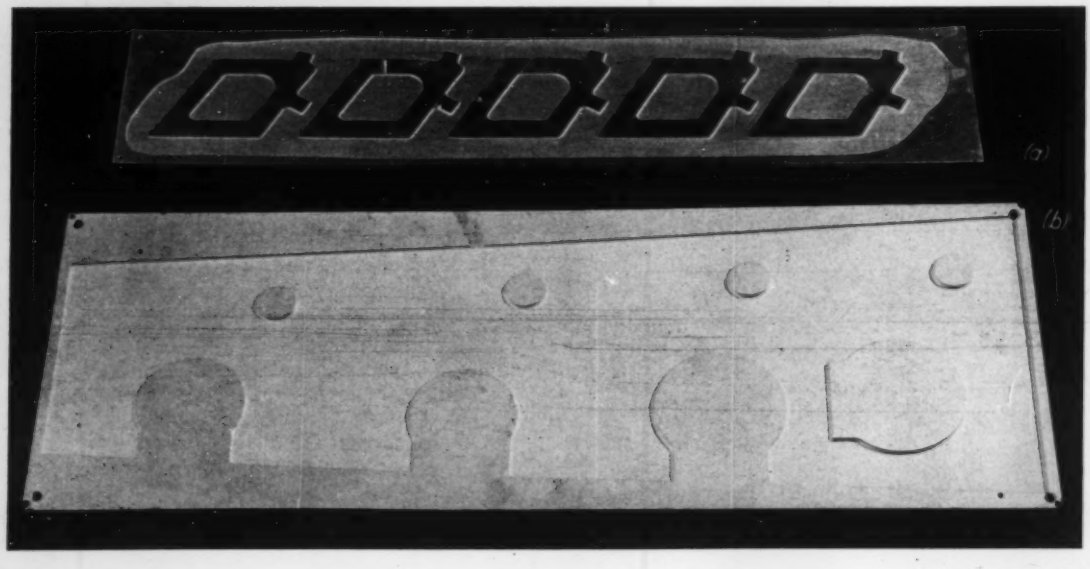


Fig. 3—Left—Contoured fuselage skin is chemically milled for weight savings. Remaining web is too thin for production by other methods.

Fig. 4—Below—Strip with five small access doors, *a*, is milled as a unit. Parts are later cut and trimmed to size. Wing rib with integral stiffeners, *b*, demonstrates intricate pattern. The step is produced by a double unmasking operation. Part is masked by dipping, then areas to be chemically milled are scribed and the masking removed from area of deepest cut. Scribe marks around unmasked areas are covered with lead tape and part is etched to depth of the step. Remaining scribed area is unmasked and the part is etched to depth of the shallower cut. In this case, the step is 0.020-in., so this amount is removed on first cut. Part is 0.188-in. sheet; shallower cut leaves web thickness of 0.070-in. and deeper cut leaves 0.050-in.



required amount of metal has been removed, the part is taken from the etching tank and rinsed.

Action of the etching solution leaves a black smut on the surface of the part. This is removed by immersing the part in a deoxidizing solution. After deoxidizing and rinsing, masking is removed from areas that were not etched and the part is complete.

Chemical milling shows no evidence of altering the structural characteristics of the metal. Thus, chemically milled sheet or plate stock has structural characteristics comparable to that obtained by conventional machining.

Design Suggestions

1. Maximum size of part that can be chemically milled is governed only by the tank size available.

2. Chemical milling is most economical where no masking is required. Masking solution is expensive and proper masking may require several coatings. The amount and type of scribing (cutting off masking where part will be etched) also affects the cost. There must be no requirement for masking of inaccessible areas.

3. Generally, the best application for chemical milling is in the removal of large areas to a depth of not more than ½-in.

4. While tolerances of ±0.001-in. are obtainable,

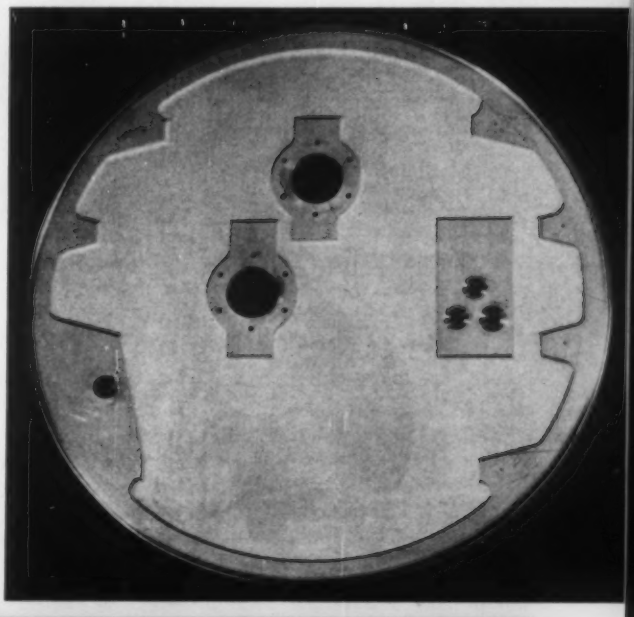
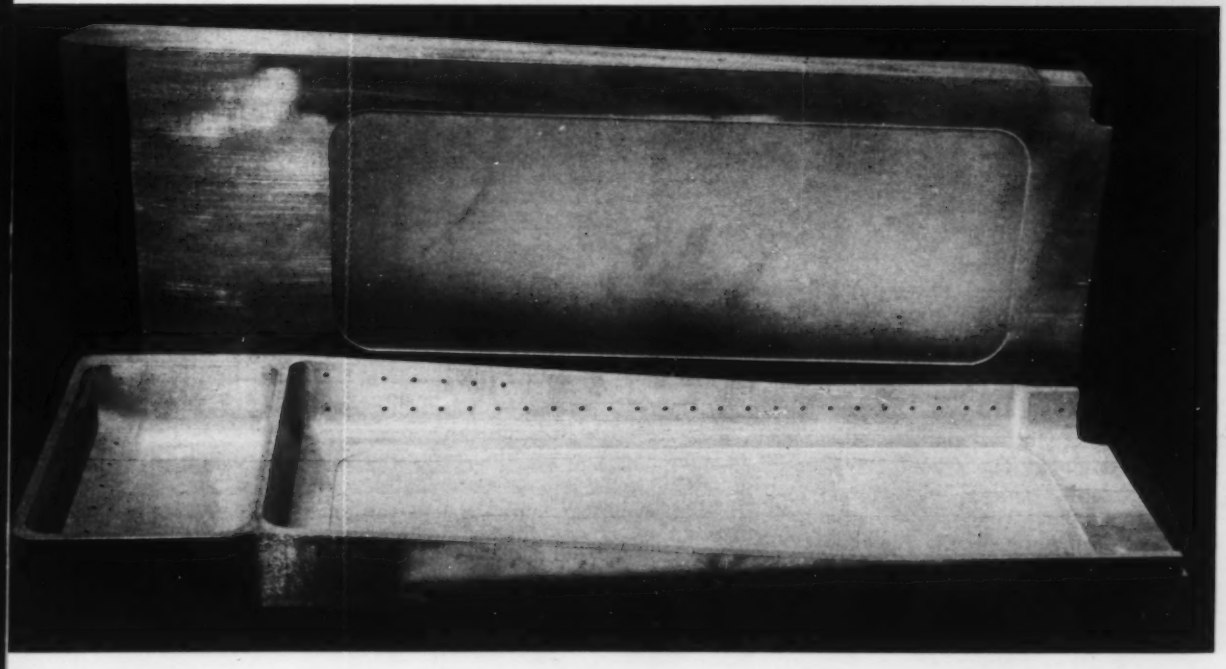


Fig. 5 — Right — Fuel tank bulkhead is chemically milled from 0.320-in. aluminum sheet to avoid fasteners and sealing problems associated with built-up bulkheads of sheet metal with stiffeners. Depth of cut is 0.260-in., leaving 0.060-in. web. Holes and peripheral cuts are machined after chemical milling.

Fig. 6—Below—Fitting exemplifies part which is not applicable to chemical milling. Part was produced experimentally by machining from 2-in. plate and then chemically milling to reduce thickness of central web. Part was started on milling machine and could have been finished there at less cost. Masking of part, due to complex shape, was very expensive. Part could not be entirely chemically milled because of depth of cut and necessity of producing small fillet radii.



the holding of such close tolerances raises the cost. Generally, length and width tolerances of ±0.060-in. and thickness or depth of cut tolerances of −0.000, +0.005-in. will be found more practical.

5. Surface finish depends upon initial finish, depth of cut, and type and temper of the material. As depth of cut increases, the final finish becomes rougher. Surface finish is always less than 125 microinches rms on surfaces parallel to the grain, when properly processed. Average surface roughness is from 50 to 90 microinches rms.

6. Warpage produced by chemical milling is negligible because of the slow rate of etching. However, if deep cuts are taken on one side of a curved surface having locked-in stresses, the relief of these stresses on one side may produce warping.

7. Fillet radii cannot be controlled. They are determined by depth of cut and material alloy. Inside corners and plan-view corner radii take a spherical shape with a radius nearly equal to the depth of cut. Outside corners are only slightly rounded.

8. Castings are difficult for chemical milling due to the porosity and nonhomogeneity of the material, which produces an uneven etching rate.

9. Welded parts can be chemically milled, but only with special handling.

10. Surface irregularities such as dents, scratches, surface waviness and thickness variations are reproduced but not enlarged injuriously. However, a part that is scratched sufficiently to be rejectable before chemical-milling will probably be rejectable afterward.

11. Wall thickness may be reduced to 0.005-in. without warping or buckling.

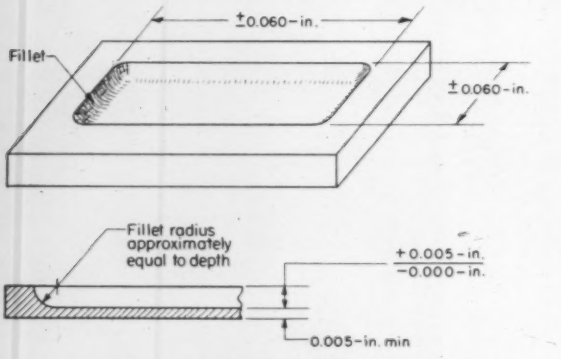
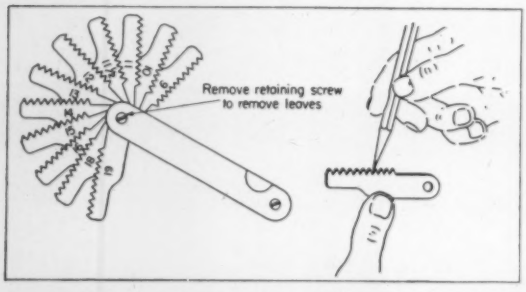


Fig. 7—Tolerances shown can be readily produced by chemical milling.

Tips and Techniques

Drawing Screw Threads

The drawing of screw threads, when conventional symbols cannot be used, can be speeded by using leaves from a thread-pitch gage. The gages



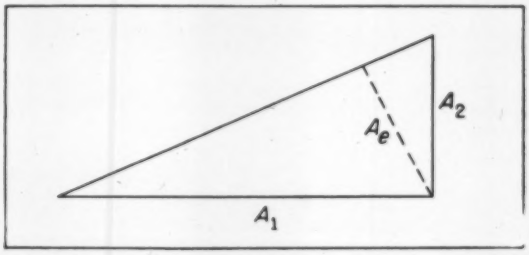
are accurately finished and permit rapid and convenient thread drawing. The leaf with the required pitch is removed from the holder with a screwdriver.—PHILIP E. MCCAFFERTY, *Stanwood, Iowa.*

Hydraulic Circuit Restriction

In hydraulic circuits, it is sometimes desirable to find the effective area of a restriction, A_e, equivalent to two restrictions, A_1 and A_2, in series. For example, find an orifice that will replace two series orifices to result in the same head-flow relationship. This equivalent area, A_e, may be found from the expression:

$$A_e = \frac{A_1 A_2}{A_1^2 + A_2^2}$$

A simple graphical solution to the problem may be obtained by constructing a right-triangle, the



length of whose legs are A_1 and A_2. The equivalent orifice area is then the altitude of the triangle, using the hypotenuse as the base.—G. M. WIDELL, *South Bend, Ind.*

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New methods for analytically determining

States of Stress

- **Plane States of Principal Stress**
- **Maximum Shear Stress**

By John O. Predale
Associate Professor of Mechanical Engineering
Newark College of Engineering
Newark, N. J.

MANY states of stress can be associated with a given point in a two-dimensional stress field, and two are particularly important to the designer. These are the *principal state of stress* and the *state of maximum shearing stress.* This article presents a simple analytical procedure for determining the orientation and magnitudes of the stress components which define the two important states.

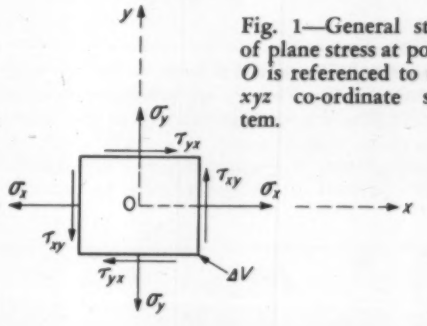

Fig. 1—General state of plane stress at point *O* is referenced to the *xyz* co-ordinate system.

Key factors leading to simplification of conventional analytical methods are: (1) the invariant property of the algebraic sum of normal stresses, (2) the uniqueness property of the states of principal stress and maximum shearing stress (excluding the isotropic state of stress), (3) the notation used for the principal stresses, and (4) the sign convention adopted for shearing stresses.

Fig. 1 defines the general state of stress at an arbitrary point *O* in a two-dimensional stress field as referenced to the *xyz* co-ordinate system, the *z* axis being directed upward from the page. The rectangular block of material, ΔV, surrounding point *O* and having its edges parallel to the axes of the co-ordinates is a significant part of the definition.

This element is assumed to be infinitely small with the result that associated body forces and stress variations are negligible. An equally important assumption is that the dimensions of ΔV, although infinitesimal, are large compared with the mean free path of the molecules. This latter assumption is necessary if the macroscopic treatment of matter is not to be invalidated.

Since ΔV is in equilibrium, it follows that

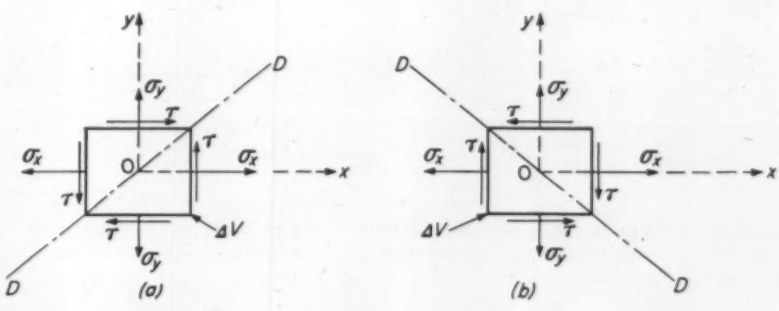

Fig. 2—Possible configurations for a system of shearing stresses when referred to *xyz* co-ordinates.

$$\tau_{yz} = \tau_{xy} \qquad (1)$$

Thus the condition of equilibrium requires not only numerical equality of the four shearing stress components but also that they meet at opposite corners of the element.

For the case of plane stress and for a given co-ordinate system, a system of shearing stresses can have only two configurations. For example, with respect to the xyz co-ordinate system, the configurations would be as shown in Fig. 2. Observe that the subscripts for τ have been omitted in view of Equation 1.

The shearing stresses in Fig. 2*a* will be considered positive, and those in Fig. 2*b*, negative. This sign convention can best be expressed with respect to the *shear diagonal* which is defined as the diagonal through the opposite corners of the element where the arrows meet (*DD* in Fig. 2). Thus, the shearing stresses have the same sign as the slope of the shear diagonal. The sign of the slope is established with respect to the co-ordinate system under consideration.

In Fig. 3, the state of stress is defined with respect to a new co-ordinate system. The slope of the shear diagonal is seen to be negative relative to the x_1 and y_1 axes. Consequently, the shearing stresses are negative also.

The general transformation of plane stress at a point is a familiar problem. For this reason, the subsequent treatment is brief and derivations have been omitted.

The problem is: given the state of stress at an arbitrary point O in a two-dimensional stress field relative to the xyz co-ordinate system, Fig. 4, determine the state of stress at O with respect to a new co-ordinate system x_1y_1z defined by the angle θ, Fig. 5.

The solution is given by the following equations:

$$\sigma_{x1} = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta + \tau \sin 2\theta \qquad (2)$$

$$\sigma_{y1} = \sigma_x \sin^2\theta + \sigma_y \cos^2\theta - \tau \sin 2\theta \qquad (3)$$

Nomenclature

$x_P\ y_P\ z$, $x_{aP}\ y_{aP}\ z$, $x_{bP}\ y_{bP}\ z$ and $x_{cP}\ y_{cP}\ z$ denote the principal co-ordinate systems as defined by the roots θ_P, $\theta_P + (\pi/2)$, $\theta_P + \pi$ and $\theta_P + (3\pi/2)$, respectively, of Equation 6.

$x_S\ y_S\ z$ denotes the maximum shearing-stress co-ordinate system that is displaced 45 degrees counterclockwise from the principal co-ordinate system $x_P\ y_P\ z$.

$x_{aS}\ y_{aS}\ z$ denotes the maximum shearing-stress co-ordinate system that is displaced 45 degrees clockwise from the principal co-ordinate system $x_P\ y_P\ z$.

dV = Body subelement surrounding point O with sides parallel to the axes of associated co-ordinate system.

dV_P = Body subelement surrounding point O with sides parallel to the axes of the principal co-ordinate system $x_P\ y_P\ z$.

dV_S = Body subelement surrounding point O with sides parallel to the axes of the maximum shearing-stress co-ordinate system $x_S\ y_S\ z$.

α = Angle by which the arbitrary co-ordinate system $x_2\ y_2\ z$ is displaced from the principal co-ordinate system x_Py_Pz, radian.

θ = Angle by which the arbitrary co-ordinate system $x_1\ y_1\ z$ is displaced from the xyz co-ordinate system, radian.

θ_P = Angle by which the principal co-ordinate system $x_P\ y_P\ z$ is displaced from the xyz co-ordinate system, radian.

σ_{iq} = Normal stress component with line of action along the i_q-axis, where $i = x$ or y; e.g., σ_{xaP} has a line of action along the x_{aP}-axis, psi.

τ = Shearing stress component parallel to xy-plane and acting on each of the four lateral faces of relevant body element, psi.

Subscripts

1 identifies properties in an arbitrary co-ordinate system which is defined relative to the xyz system.

2 identifies properties in an arbitrary co-ordinate system which is defined relative to the principal co-ordinate system x_Py_Pz.

xy means parallel to the xy-plane and the y-axis.

yx means parallel to the xy-plane and the x-axis.

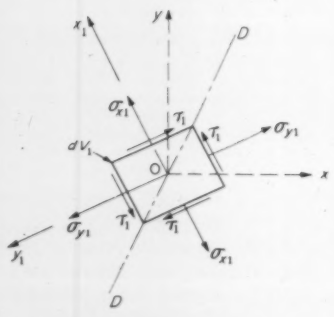

Fig. 3—Positive shearing stresses made negative by rotation of co-ordinate axes.

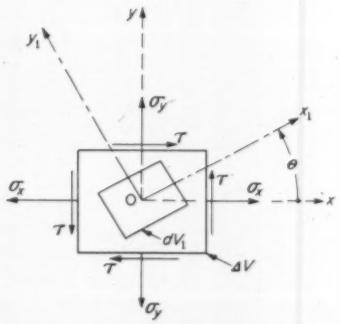

Fig. 4—State of stress at O relative to xyz co-ordinate system.

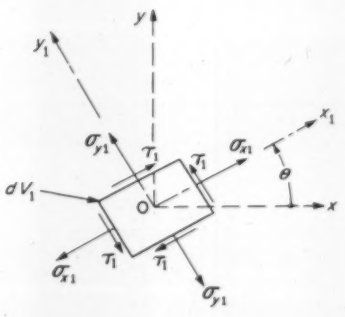

Fig. 5—State of stress at O relative to x_1y_1z co-ordinate system.

$$\tau_1 = \frac{\sigma_y - \sigma_x}{2} \sin 2\theta + \tau \cos 2\theta \qquad (4)$$

Care must be taken in assigning the proper algebraic signs to the quantities appearing on the right-hand side of these transformation formulas. Angle θ is considered positive when measured counterclockwise and negative when measured clockwise. Normal stresses are positive when tensile in nature and negative when compressive.

It will be noted that all stresses appearing in Figs. 4 and 5 are positive. Consequently, when a negative value is obtained for a normal stress, it means that the stress is compressive. A negative value for τ_1 would indicate that the associated shear diagonal has a negative slope relative to the x_1 and y_1 axes.

Adding Equations 2 and 3,

$$\sigma_{x1} + \sigma_{y1} = \sigma_x + \sigma_y \qquad (5)$$

Thus, the state of plane stress at a point has

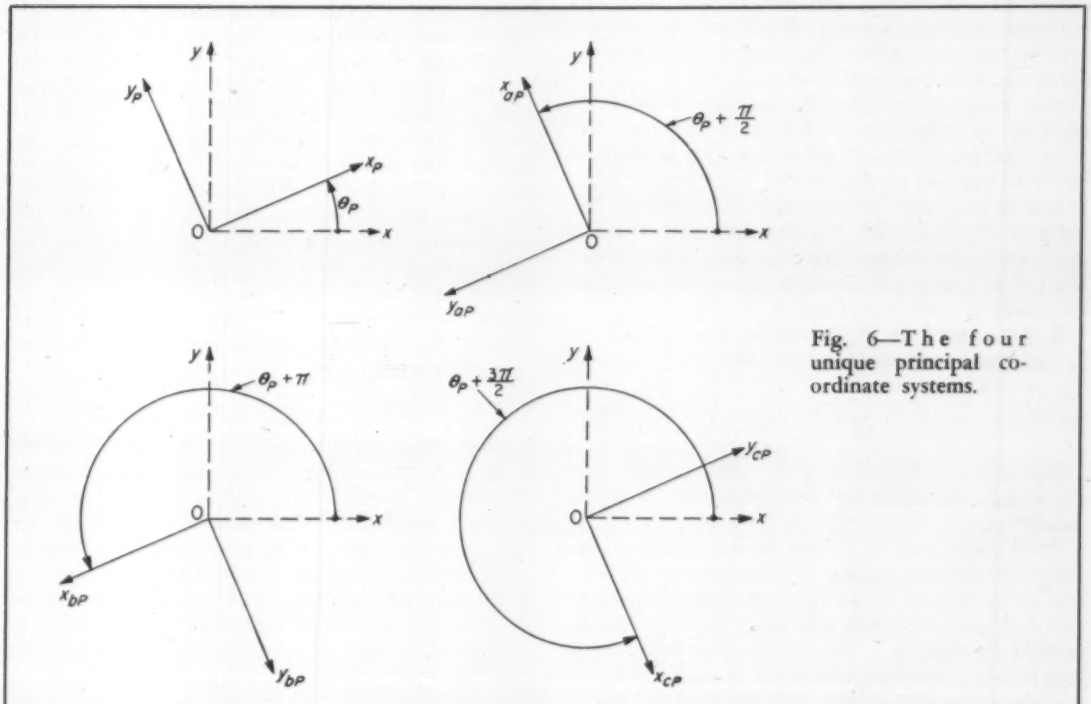

Fig. 6—The four unique principal coordinate systems.

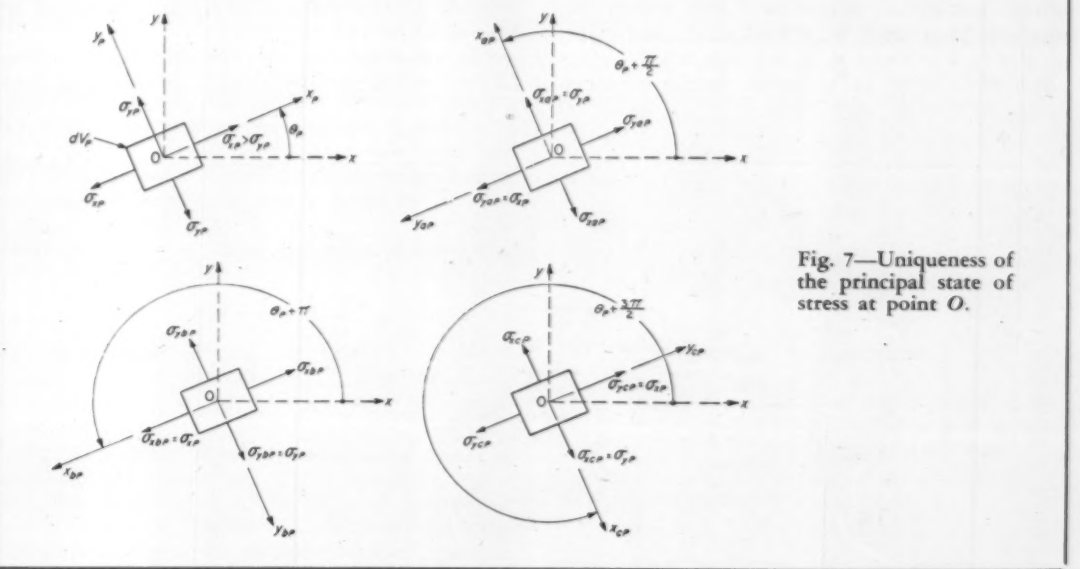

Fig. 7—Uniqueness of the principal state of stress at point *O*.

the property that the algebraic sum of the normal stresses is constant and independent of the co-ordinate system used as reference.

The usefulness of this property is that it provides a convenient means of determining the stress σ_{y1}, once σ_{x1} has been calculated from Equation 2. That is, Equation 5 solved for σ_{y1} is simpler than Equation 3.

An important special case of the general transformation problem is the plane state of principal stress. The identifying features of this state are that shearing stresses are absent and the normal stresses are the algebraic maximum and minimum for the point under consideration.

It is expedient to identify the body subelement used in the definition of this state of stress. Let it be designated dV_P. Observe that this is the previously employed subelement dV_1 appearing in Figs. 4 and 5 but with a particular orientation. The sides of dV_P constitute the principal planes. Basic conclusions can be reached regarding the orientation of dV_P and the stresses acting on its sides by working with Equations 2, 3 and 4.

If Equation 2 is differentiated with respect to θ, and the result set equal to zero, the result is

$$\tan 2\theta = \frac{2\tau}{\sigma_x - \sigma_y} \qquad (6)$$

Similarly, if Equation 3 is differentiated and the result set equal to zero, Equation 6 is obtained again.

From these results, it can be deduced that the principal stresses acting simultaneously on dV_P are perpendicular to each other. The absence of shearing stresses from the sides of dV_P can be verified by setting τ_1 equal to zero in Equation 4 and thereby obtaining Equation 6 once again.

Consider next the roots of Equation 6. For a given value of $2\tau/(\sigma_x - \sigma_y)$, it is clear that an infinite number of values of θ will satisfy the equation. These may be written as θ_P and $\theta_K = \theta_P + K(\pi/2)$, where $K = \pm 1, \pm 2, \pm 3, \cdots$.

The root θ_P is to be given special meaning. When $\tan 2\theta > 0$, θ_P will denote the smallest positive root of Equation 6 ($0 < 2\theta_P < \pi/2$). When $\tan 2\theta < 0$, θ_P will denote the largest (algebraic) negative root ($-\pi/2 < 2\theta_P < 0$).

It can readily be verified that the foregoing roots define four unique principal co-ordinate systems and no more. These co-ordinate systems will be denoted by x_Py_Pz, $x_{aP}y_{aP}z$, $x_{bP}y_{bP}z$ and $x_{cP}y_{cP}z$. The defining roots will be taken as θ_P, $\theta_P + \pi/2$, $\theta_P + \pi$, and $\theta_P + (3\pi/2)$, respectively, as shown in Fig. 6. It is understood that the z-axis, like the origin, is common to all the co-ordinate systems.

Notations will facilitate identification of principal stresses. When the x_Py_Pz co-ordinate system is selected, σ_{xP} and σ_{yP} will denote the principal stresses. The former are parallel to the x_P axis, and the latter parallel to the y_P axis. Similarly, in the co-ordinate systems $x_{aP}y_{aP}z$, $x_{bP}y_{bP}z$, and $x_{cP}y_{cP}z$, the principal stresses will be designated σ_{xaP}, σ_{yaP}; σ_{xbP}, σ_{ybP}; and σ_{xcP}, σ_{ycP}, respectively.

It was implied earlier that the four principal co-ordinate systems all lead to one and only one principal state of stress at a given point in a two-dimensional stress field. To demonstrate this, let it be assumed that the known state of stress at a point O, referenced to the xyz co-ordinate system, is such that

$$\sigma_x > \sigma_y > 0, \text{ and } \tau > 0 \qquad (7)$$

Then from Equations 2 and 3, upon replacing θ by each of the four roots defining the principal co-ordinate systems, one obtains the results summarized in Fig. 7. These results establish the uniqueness property of the principal state of stress. Although this important result is based on the case given by Equation 7, it can be shown to be true for all other cases except, as previously noted, the isotropic state of stress in which $\sigma_x = \sigma_y$ and $\tau = 0$.

It is now evident that the choice of principal co-ordinate system is arbitrary. The x_Py_Pz co-ordinate system defined by θ_P, the first root of Equation 6, will be used here.

The equations for the principal stresses then follow from Equations 2 and 3 by replacing θ by

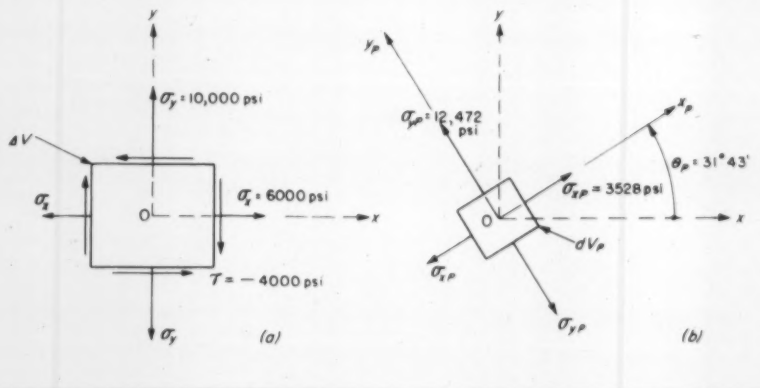

Fig. 8—Solution for Example 1.

θ_P. Thus

$$\sigma_{xP} = \sigma_x \cos^2 \theta_P + \sigma_y \sin^2 \theta_P + \tau \sin 2\theta_P \quad (8)$$

$$\sigma_{yP} = \sigma_x \sin^2 \theta_P + \sigma_y \cos^2 \theta_P - \tau \sin 2\theta_P \quad (9)$$

From Equation 5, or by adding the foregoing equations, it follows that

$$\sigma_{yP} = \sigma_x + \sigma_y - \sigma_{xP} \quad (10)$$

Because of its simplicity, this equation is recommended in lieu of Equation 9.

Example 1. The plane state of stress at a point O relative to the xyz co-ordinate system is as follows:

$$\sigma_x = 6000 \text{ psi}, \ \sigma_y = 10{,}000 \text{ psi}, \text{ and } \tau = -4000 \text{ psi}$$

Determine the principal state of stress at O.

Solution: The given state of stress is shown in Fig. 8*a*.

Substituting in Equation 6 gives

$$\tan 2\theta = \frac{2\tau}{\sigma_x - \sigma_y} = \frac{2(-4000)}{6000 - 10{,}000} = 2$$

By definition, since $\tan 2\theta > 0$, θ_P is the smallest positive root. Thus

$$2\theta_P = 63^\circ\ 26' \text{ and } \theta_P = 31^\circ\ 43'$$

The computations for σ_{xP} and σ_{yP} are as follows.

$$\sigma_{xP} = \sigma_x \cos^2 \theta_P + \sigma_y \sin^2 \theta_P + \tau \sin 2\theta_P$$

$$= 6000 \cos^2 31^\circ\ 43' + 10{,}000 \sin^2 31^\circ\ 43' - 4000 \sin 63^\circ\ 26'$$

$$= 4342 + 2764 - 3578 = 3528 \text{ psi}$$

$$\sigma_{yP} = \sigma_x + \sigma_y - \sigma_{xP} = 6000 + 10{,}000 - 3528 = 12{,}472 \text{ psi}$$

The principal state of stress at O is then as shown in Fig. 8*b*.

Inasmuch as the plane state of maximum shearing stress at a point can be readily established from the principal stresses, it is expedient to have general transformation formulas in terms of these stresses.

Fig. 9 shows the plane state of stress at a point O as referenced to an arbitrarily chosen co-ordinate system, x_2y_2z. The angle α is measured from the positive x_P-axis to the positive x_2-axis. The equations for this state of stress, assuming the principal stresses are known, can be obtained most expeditiously from Equations 2, 3 and 4.

Thus upon replacing θ, σ_x, σ_y, and τ in these equations by α, σ_{xP}, σ_{yP}, and zero, respectively, there results

$$\sigma_{x2} = \sigma_{xP} \cos^2 \alpha + \sigma_{yP} \sin^2 \alpha \quad (11)$$

$$\sigma_{y2} = \sigma_{xP} \sin^2 \alpha + \sigma_{yP} \cos^2 \alpha \quad (12)$$

$$\tau_2 = \frac{1}{2}(\sigma_{yP} - \sigma_{xP}) \sin 2\alpha \quad (13)$$

The plane state of maximum shearing stress is an important special case of the foregoing transformation problem. For this state of stress the normal stresses are equal and the associated body subelement, which will be designated dV_s, is ori-

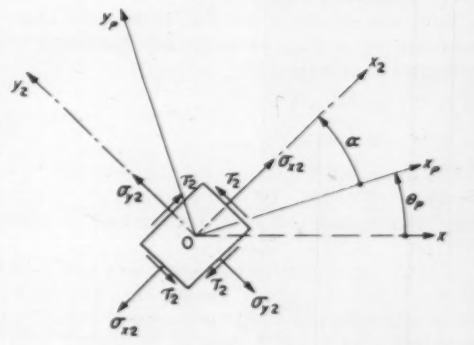

Fig. 9—Plane state of stress at O relative to x_1y_1z co-ordinate system.

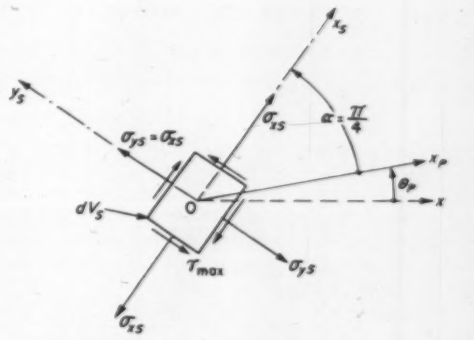

Fig. 10—The plane state of shearing stress at point O.

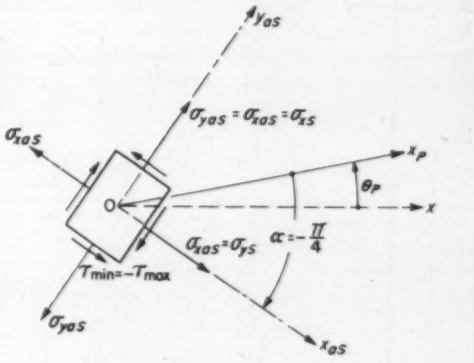

Fig. 11—The plane state of stress at point O corresponding to $\alpha = -\pi/4$.

ented 45 deg relative to dV_p, the subelement for the principal stresses.

Referring to Equation 13, it is seen that the condition $\tau_2 = \tau_{max}$ leads to the following transcendental equations:

$$\sin 2\alpha = 1 \text{ when } \sigma_{yP} > \sigma_{xP} \tag{14}$$

$$\sin 2\alpha = -1 \text{ when } \sigma_{xP} > \sigma_{yP} \tag{15}$$

The roots of Equation 14 are $\pi/4$ and $(-1)^K (\pi/4) + K(\pi/2)$, $(K = \pm 1, \pm 2, \cdots)$, and they define two and only two unique co-ordinate systems associated with dV_S.

If two representative roots, say $\pi/4$ and $(\pi/4) + \pi$, are selected, it can readily be demonstrated, by substitution in Equations 11, 12 and 13, that they lead to the same state of maximum shearing stress. It is clear then that only one of these roots need be considered.

Selecting $\alpha = \pi/4$, and denoting the corresponding co-ordinate system and normal stresses by $x_S y_S z$, and σ_{xS}, σ_{yS}, respectively, the following equations result for $\sigma_{yP} > \sigma_{xP}$.

$$\tau_{max} = \frac{\sigma_{yP} - \sigma_{xP}}{2} \tag{16}$$

$$\sigma_{xS} = \sigma_{yS} = \frac{\sigma_{xP} + \sigma_{yP}}{2} \tag{17}$$

Similarly, when the foregoing procedure is applied to Equation 15 for $\sigma_{xP} > \sigma_{yP}$, there results

$$\tau_{max} = -\frac{\sigma_{yP} - \sigma_{xP}}{2} \tag{18}$$

$$\sigma_{x\alpha S} = \sigma_{y\alpha S} = \frac{\sigma_{xP} + \sigma_{yP}}{2} \tag{19}$$

Here the root $\alpha = -\pi/4$ has been selected, and $x_{\alpha S} y_{\alpha S} z$ is the co-ordinate system defined by it.

It now remains to be shown that the root $\alpha = \pi/4$ corresponding to $\sigma_{yP} > \sigma_{xP}$, and the root $\alpha = -\pi/4$ corresponding to $\sigma_{xP} > \sigma_{yP}$, both lead to the same state of maximum shearing stress at a point. By establishing this uniqueness property it is possible to eliminate the two foregoing conditions of inequality and thereby reduce the number of equations to two.

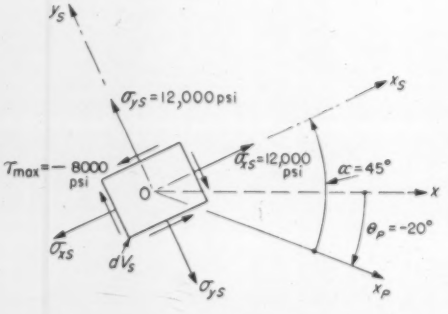

Fig. 12—Solution for Example 2.

Assume that the principal state of stress at some point O in a two-dimensional stress field is such that $\sigma_{yP} > \sigma_{xP} > 0$. Then by equations 16 and 17 the state of maximum shearing stress will appear as in Fig. 10.

Now if the root $\alpha = -\pi/4$ is used for the case under consideration, it will lead to the state of stress shown in Fig. 11. Here the shearing stress is an algebraic minimum given by

$$\tau_{min} = -\frac{\sigma_{yP} - \sigma_{xP}}{2} = -\tau_{max},$$

as can easily be verified from Equation 13. The normal stresses are, as before, equal to $(\sigma_{xP} + \sigma_{yP})/2$ in accordance with Equation 19.

Comparing the τ_{max}-system of shearing stresses in Fig. 10 with the τ_{min}-system in Fig. 11, it is clear that the two systems are the same. In view of this, the symbol τ_{min} is apparently misleading. To circumvent this, and at the same time eliminate the conditions of inequality $(\sigma_{yP} > \sigma_{xP};\ \sigma_{xP} > \sigma_{yP})$, one may write

$$\tau_{max} = \pm \frac{\sigma_{yP} - \sigma_{xP}}{2} \tag{20}$$

where the + sign corresponds with $\alpha = \pi/4$ and the − sign with $\alpha = -\pi/4$.

In the light of Equation 20 and from Figs. 10 and 11, it can be concluded that the plane state of maximum shearing stress at a point is unique. While this conclusion is based on the case $\sigma_{yP} > \sigma_{xP} > 0$, it can be shown to be valid for all other cases except the isotropic state of stress in which $\tau_2 = 0$ for all values of α.

Since both the $x_S y_S z$ and the $x_{\alpha S} y_{\alpha S} z$ co-ordinate systems associated with dV_S lead to the same plane state of maximum shearing stress, it is evident that only one of these need be employed in a given problem.

If the $x_s y_s z$ co-ordinate system defined by $\alpha = \pi/4$ is selected, the governing equations will be

$$\tau_{max} = \frac{\sigma_{yP} - \sigma_{xP}}{2} \tag{21}$$

and

$$\sigma_{xS} = \sigma_{yS} = \frac{\sigma_{xP} + \sigma_{yP}}{2} = \frac{\sigma_x + \sigma_y}{2} \tag{22}$$

Example 2. The principal state of stress at some point O in a two-dimensional stress field is: $\sigma_{xP} = 20{,}000$ psi, $\sigma_{yP} = 4000$ psi, and $\theta_P = -20$ deg. Determine the state of maximum shearing stress at O.

Solution: Substituting in Equations 21 and 22 gives $\tau_{max} = -8000$ psi and $\sigma_{xS} = \sigma_{yS} = 12{,}000$ psi.

The required state of stress is then as shown in Fig. 12.

How to design for

Machining Heat-Resistant Alloys

By R. D. Halverstadt
Aircraft Gas Turbine Dept.
General Electric Co.
Schenectady, N. Y.

IN general, the higher the high-temperature shear strength of a material the more difficult it is to machine. This method of estimating machinability is qualitative rather then quantitative since abrasiveness and many other factors enter into the composite machinability rating. High-temperature strengths of several materials are listed in Table 1.

The machinability of these materials also falls roughly in the same general order but with some notable exceptions. Note that Hastelloy B falls between 321 stainless and Timken 16-25-6 on strength, but actually it is as difficult to machine as the M-252 which has the highest strength of any in the list.

At 100 surface feet per minute the tool life for machining M-252 is only about 10 minutes. Where the cutting speed is lowered to 60 sfpm the tool life is increased to 60 minutes, but when the speed is further lowered the tool life drops off to a value lower than at the high speeds. Thus, with this particular set of conditions it is virtually impossible to obtain a tool life longer than 60 minutes, and the actual cutting speed range is limited from 100 to 60 sfpm.

It was originally intended to machine the M-252 in solution-treated state. However, the difficulty of machining the solution-treated forgings launched a machinability

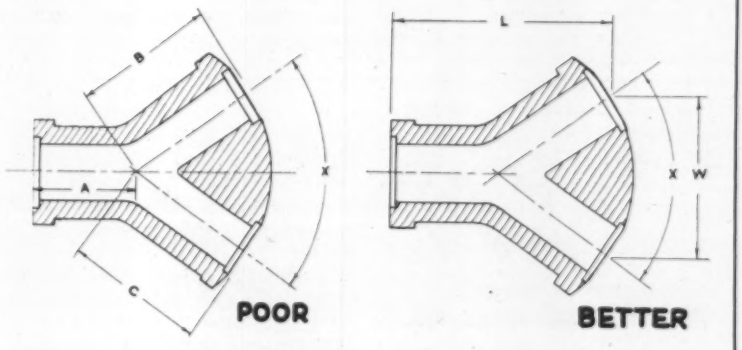

Fig. 1—Methods of dimensioning.

Table 1—Typical High-Temperature Strengths

Material	1000 hr Rupture Strength at 1200 F (psi)
Lapelloy	15,000
310 stainless steel	17,000
321 stainless steel	20,000
Hastelloy B	34,000
Timken 16-25-6	25,000
A-286	46,000
S-816	50,000
M-252	78,000

investigation. The results show the tool life for the solution-treated and aged material is about twice the tool life obtained on the solution-treated stock at equivalent speed. Thus, proper material selection with the proper heat-treatment is the first and one of the cardinal steps in designing for practical production.

Dimensions: After the material is on hand and rough or finish machined, the next operation is usually layout work. This consists of making sure that the entering machining cut on a casting or forging is taken in a position which insures complete clean-up of the part. Layout is necessary for certain operations such as: drilling, milling, shaping and boring. On high-production parts the layout may be done only on the first parts and subsequent operations may be performed using jigs and fixtures. However, no matter which method is used, the designer can insure accurate low-cost layout and fixture design problems with a minimum of scrappage if the parts are dimensioned properly. The following rules apply:

1. Start all dimensions from a finite surface. Imaginary points or lines are difficult to use for layout, fixture design, and during the actual machining process.
2. Use a common base line for all dimensions. This will greatly simplify stack-up problems and will help in manufacturing.
3. Discard the time-worn theory that double dimensioning is not permitted. There are times when double dimensioning will greatly simplify both design and manufacturing problems. However, this tool should be used only where needed.

A simple example of two types of dimensioning is shown in Fig. 1. This is a schematic representative of an actual part. When the part was first designed it was dimensioned as shown in the left view. With the original dimensions the part was almost impossible to lay out, manufacture, and inspect. However, when the dimensions were changed as shown in the right-hand view, no major problems were encountered. The moral is: dimension from a real surface or accessible centerline. Admittedly, dimensioning is not specifically a high-temperature alloy problem but all problems are accentuated with high-temperature alloys.

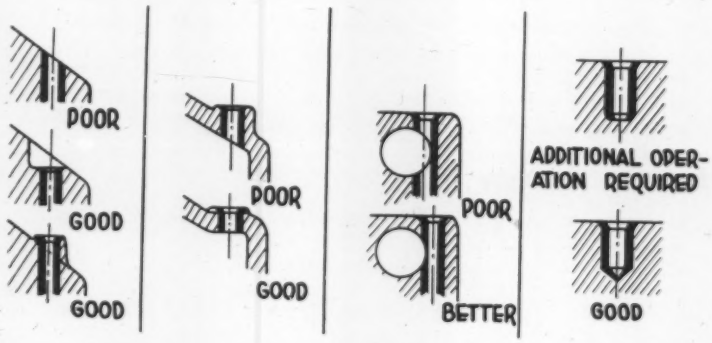

Fig. 2—Examples of design for drilling.

Drilling: Drilling high-temperature alloys has proved troublesome. Some drilling problems can be solved most advantageously on the drafting board. Some of the changes that can be made only in the design stages are shown in Fig. 2 and are covered by the following rules:

1. Do not design for drilling into or through an angular surface. Remember that a drill is a tool with a rather high length/area ratio and, therefore, any side thrust applied will result in considerable deflection and resulting inaccuracies of hole location. Even if a jig is used, the side thrust will cause rapid jig bushing and drill wear. Drilling through an angular surface presents a similar problem. As the drill goes through and cuts only on one side, a high strain is thrown on the drill.
2. Do not design a hole to be drilled with less than about 200 deg of arc. A drill is supported radially by itself and, therefore, will lead-off, causing scrappage for dimensional reasons if less than ½-in. hole is drilled.
3. Try to design for one operation. This is particularly true for the austenitic high-temperature alloys that are subject to work-hardening where it may be difficult to start a second operation because of work-hardened surfaces resulting from the first.
4. Make "small" holes as large and shallow as possible. This is extremely important for the high-temperature alloys because of extra force required to cut these alloys. The ability of a drill to cut is, for one thing, a function

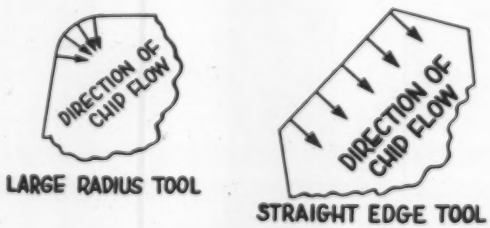

Fig. 3—Effect of tool form on chip flow.

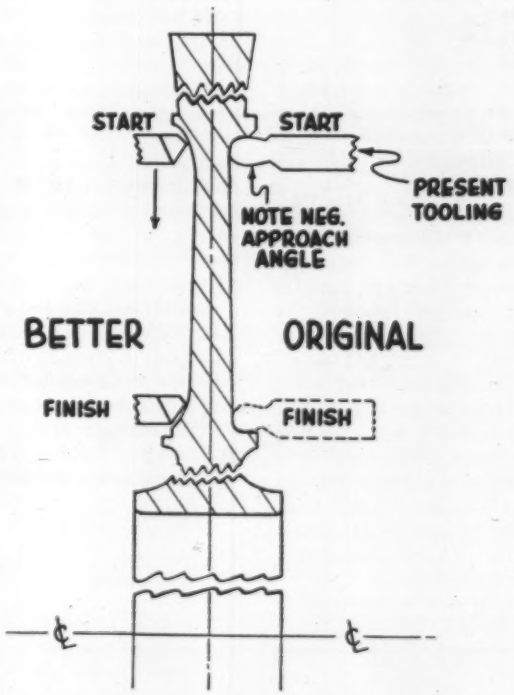

Fig. 4—Designs for tracing a disk.

of the torsional rigidity of the drill. Torsional rigidity aside from material is largely an inverse function of length/area.

5. Make hole location tolerances as liberal as possible. This is important in that if an extremely accurate location is required the tool engineer will need to use a long drill bushing. Long drill bushings prohibit the use of short drills and, therefore, the length/area ratio will go up, and the torsional rigidity and the ability to drill the hole will come down.
6. Eliminate drilling on nonrigid parts. Finally, to be considered in all cases of drilling high-temperature alloys is the tendency to work-harden. If a part is not rigid the part will deflect while the forward motion of the drill is building up enough force to penetrate the material. By the time sufficent force is built up, the material will have been so work-hardened by the rotation of the drill point, that if the drill is able to penetrate at all it may be a one-hole proposition, since immediate drill failure will result. This is the reason that sheet metal and other high-temperature alloy parts which lack rigidity are so difficult to drill.

Tapping: Tapping is a difficult job even on conventional materials and of course is much more difficult on the high-temperature alloys. Again, the fact that the torsional strength decreases faster than the requirements for torsional strength as tap size decreases cannot be eliminated completely by the designer. However, some steps can be taken:

1. Tap through whenever possible. This permits the use of spiral point taps which have proven superiority for these alloys.
2. Reduce the percent of full thread. This will effectively reduce the torque requirements. Recent studies have shown that tapped holes can be just as strong with a reduced percentage of full thread.
3. Use as large a tap as possible that will satisfy design requirements.
4. Use as short a length of thread as possible.
5. Avoid extremely coarse-pitch threads.
6. Leave adequate space at bottom of tapped holes.

Turning: Turning, as well as almost any other process on the high-temperature alloys, hinges around the tool geometry. The tool geometry is sometimes set by the product designer and cannot always be changed at will by the process engineer. The most desirable geometry for cutting high-temperature alloys consists of:

1. Positive rake angles.
2. Small nose radii blended into the high lead angle and low end cutting edge angle.
3. High side cutting edge angle.
4. Low end cutting edge angle.

In order to make use of such a tool it is necessary to use chamfers wherever possible instead of radii, and to design shoulders and other shapes so that this type geometry can be utilized.

The use of a large radius is particularly undesirable because all parts of the chip tend to move toward the center of the radius as shown in Fig. 3. This crowding or balling of the chip tends to inhibit smooth, even chip flow. This causes higher forces and greater plastic deformations which results in a greater degree of strain hardening. The straight cutting edge allows a smooth, even unidirectional flow of the chip, which is easily broken and handled.

Conversely, the use of a large chamfered shoulder is desirable because a high cutting-edge angle distributes the chip load over a large area of the cutting edge. For any one depth of cut and feed the volume per revolution will always be the same, but the high-side cutting-edge angle allows more of the cutting edge to work. The additional length of tool contact also permits greater heat-transfer area which tends to reduce the tool temperature. The lower forces and temperature alone would permit longer tool life at any one set of conditions. A secondary effect is

that this inhibits the formation of a built-up edge which has a widely known undesirable effect on finish and will tend to cause chipping when it flakes off from the tool's cutting edge. Also, the lower forces tend to reduce the amount of strain or work-hardening which takes place.

Thus, whenever a shape is designed for tracing or other operations on which these principles cannot be utilized, the machinability is considerably lowered. Fig. 4 illustrates this point. The only tool that could trace such a shape would be a round-nose tool with negative approach angles on both sides. This type tool would violate all of the principles previously set down. It would not be an impossible shape but it would be undesirable.

Another example is shown in Fig. 5. This internal shape would be extremely difficult to machine, measure and inspect. If either one end could be left open or a two-piece construction adopted, manufacturing would be greatly facilitated. Another instance can be seen in the designs of Fig. 6. The lower design can be traced all in one direction, utilizing correct tool principles. These problems are not always easy to solve, but application of the principles will increase ease of manufacture.

Geometrical Complications: In turning and boring the high-temperature alloys all deep slots or complicated shapes should be avoided. A deep slot can only be machined with a tool that is essentially a simple cantilever beam with a load applied at the extreme end. The result will be chattering caused by large deflection. The tool will dull much more rapidly, will tend to "dig-in" to the work and in many instances will break, causing, in the extreme case, scrappage of the workpiece.

On any deep slot or difficult to produce shape, it is sometimes necessary to use low feeds to cut down on chatter and deflection. This low feed causes the tool to cut in the work-hardened layer resulting from the previous pass. This causes excessive wear and tool chippage. These factors rapidly accentuate the whole force problem.

Not only are initial forces much higher for the high-temperature alloys but they increase with tool wear at several hundred times the rate as when machining 4340 steel.

Forces can also have an extremely adverse effect on the work since in many instances the parts are just not rigid enough to withstand the force that the tool imposes.

These considerations lead to the following principles for turning or general cutting design:

1. Design shapes that can be traced with one side of a cutting tool so that proper rake and lead angles can be used.
2. Design gradual shape changes so that the tool engineer can take full advantage of the most desirable type geometry for high-temperature alloys.
3. Avoid deep slots.
4. Avoid undercuts or otherwise difficult shapes where nonrigid tools of incorrect geometry must be used.
5. Design simple shapes that can be made with single point tools instead of form tools.

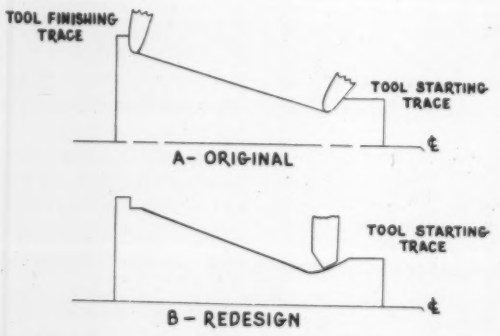

Fig. 5—Design for tracing an internal shape.

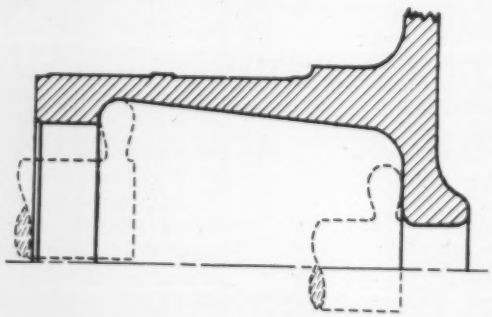

Fig. 6—Design for tracing a shaft.

Milling: The general principles which apply to the other machining operations also apply to milling. From a processing standpoint, it would be preferable to chamfer into or out of a milled step instead of designing for a 90 deg step. The use of a chamfer instead of a radius should apply throughout on any design which must be milled. The latter is true no matter what the type of cut or shape may be. Even on conventional materials it is cheaper to make chamfers than radii since accurate radii are difficult to grind on most types of milling cutters.

The most difficult type of milling to be performed is "end milling." This is true because of the large difference between "climb" cutting and "conventional" cutting, Fig. 7.

In climb cutting the tool meets the work at some relatively sharp

angle and, therefore, travels a minimum distance through the work-hardened layer until it begins to cut virgin material. The tool leaves the cut from beneath the surface so that there is a minimum amount of rubbing and scraping, and subsequent work-hardening of the surface. In conventional cutting the tool "skives" along the surface until it enters the cut with a depth of essentially zero and then travels along the cut at almost zero depth where it must cut through work-hardened material for a large percentage of its travel. This results in rapid and in some instances almost instantaneous cutter dulling and failure.

The geometry of end milling dictates a conventional type cut on one side. The result is that end milling on some alloys is an almost impossible task. Also, if the end mill must be entered into the cut axially, the center portion tends to cause work-hardening and ultimate failure. Therefore, if a slot or keyway must be cut, it would be best to design it as shown on the right side of Fig. 8.

This type slot can then be either cut with a side mill or at least the end mill can enter from the end of the piece. Fig. 9 shows a typical design that proved almost impossible to end mill from high-temperature alloy and also shows the redesign which was considerably easier to manufacture. The reason, of course, was that a side mill was plunged into the part and then traversed along the part in a climb cut fashion.

Any shape, the counterpart of which could be produced by turning, is much more difficult to produce with a milling type cut. Milling of necessity is an intermittent cut and, therefore, the tool is much more subject to chipping, breaking, and rapid dulling. Any design where forces, work hardening, and rapid tool dulling from lack of rigidity or other causes, occur should be avoided.

Surface Finish and Surface Damage: Surface finish and dimensional tolerance are tied closely together on any material, and certainly the high-temperature alloys are no exception. On long parts or parts on which the finished area is large, it is extremely difficult to hold the size and finish tolerances because of tool wear. Cost as a function of finish and tolerance reduction is exponential.

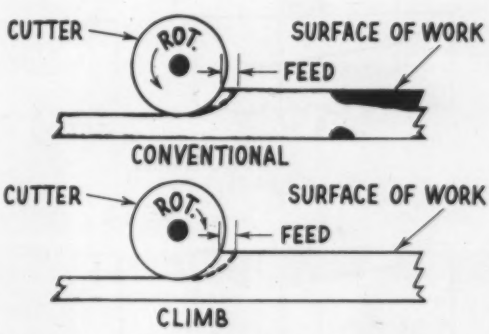

Fig. 7—Climb and conventional milling cuts.

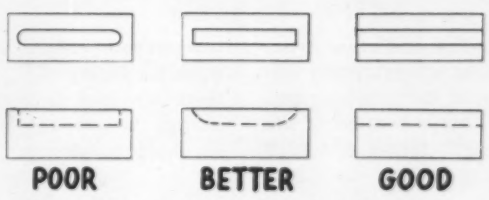

Fig. 8—Designs for milled slots or key-

Several facts have been learned about the high-temperature austenitic alloys:

1. Ductile alloys such as A-286 are difficult to finish because of rapid tool wear and built-up edge on the tool.
2. It is easier to obtain a good finish in the aged or hardened state.
3. It is easier to get a good finish on the "harder" alloys such as M-252 than it is on the softer alloys such as A-286.

A recent study conducted at General Electric shows that on facing cuts on a typical compressor wheel material, even under rigid laboratory conditions, it is difficult to obtain finishes on facing cuts of 32 microinches average roughness. The findings proved that it is not feasible under production conditions to attempt to get better than 63 microinches with ordinary available cutting methods.

Many of the thin, light aircraft parts designed today are exceedingly difficult to manufacture. This difficulty is accentuated with the high-temperature alloys because of their tendency to work-harden and the resulting residual machining stresses. In grinding, the residual tensile stresses can also reach prohibitive values. It is, therefore, well to design all parts so that ideal cutting-tool geometries can be used. In this way stresses will be minimized and the attendant distortions will not be troublesome.

Grinding: Grinding can severely damage the surface of high-temperature alloys. Measurements have been made by the author which show surface damage from residual stresses up to 0.025-in. deep, even though the measured surface finish is excellent. The designer can help to alleviate this problem by making tolerances and finish requirements as liberal as possible. This will permit the use of a "free cutting" grinding action instead of a "burnishing" type which might cause surface damage.

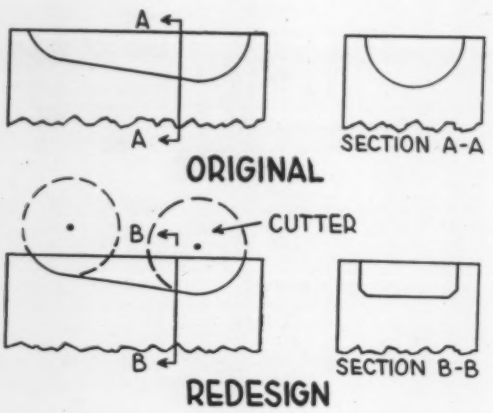

Fig. 9—Improvement of design for a milled slot.

Thread grinding and other types of form grinding are extremely difficult on some of the high-temperature alloys. This is because of the high unit cutting forces and high temperature created coupled with work-hardening of the work. It is, therefore, best to make any form change as gradual as possible so no sharp corners must be ground.

From a paper entitled "Design for Machining Heat Resistant Alloys" presented at the ASTE Annual Meeting in Houston, Texas, March, 1957.

How to improve drawing readability with

Graphic Illustration

By Frederick Jantz

Senior Design Group Leader
Graphic Illustrations
Oldsmobile Div.
General Motors Corp.
Detroit

MANY manufacturers have replaced complex orthographic assembly drawings with another type of drawing known as a graphic illustration, Fig. 1. This graphic drawing is an actual production drawing containing part numbers, notes and dimensions. It is drawn to a perspective scale as soon as basic design information is available, and generally replaces, rather than supplements, certain orthographic drawings.

Graphic illustrations which replace roll-size installation drawings consist of units of multiple sheets, each sheet a part of the installation and drawn to a size not larger than 2 x 3 ft. If a change occurs, only one sheet of the installation is affected. Many times, detail changes are not necessary on a graphic illustration. With multiple sheets, special attention is given to sequence of operation and assembly methods. The system also has the advantage of isolating special conditions to allow those concerned with particular portions of installations to focus attention on one problem.

Graphic illustrations are not limited to manufacturing. They are being extended to sales departments, dealer training and advertising, and to purchasing departments for vendor discussion. In service departments they are used in catalogs, maintenance manuals, overhaul manuals and training literature. Efficient use of graphic illustrations is assured by establishing a central originating source within a publications department. Requests for illustrations are directed to and processed by a separate graphic illustrations group.

Preparation of a graphic illustration is aided by:

1. Isometric and related types of projection.
2. Freehand sketches.
3. Photography.
4. Special drawing devices and machines.
5. Perspective grids.

The most popular method is based on the perspective grid which has predetermined vanishing

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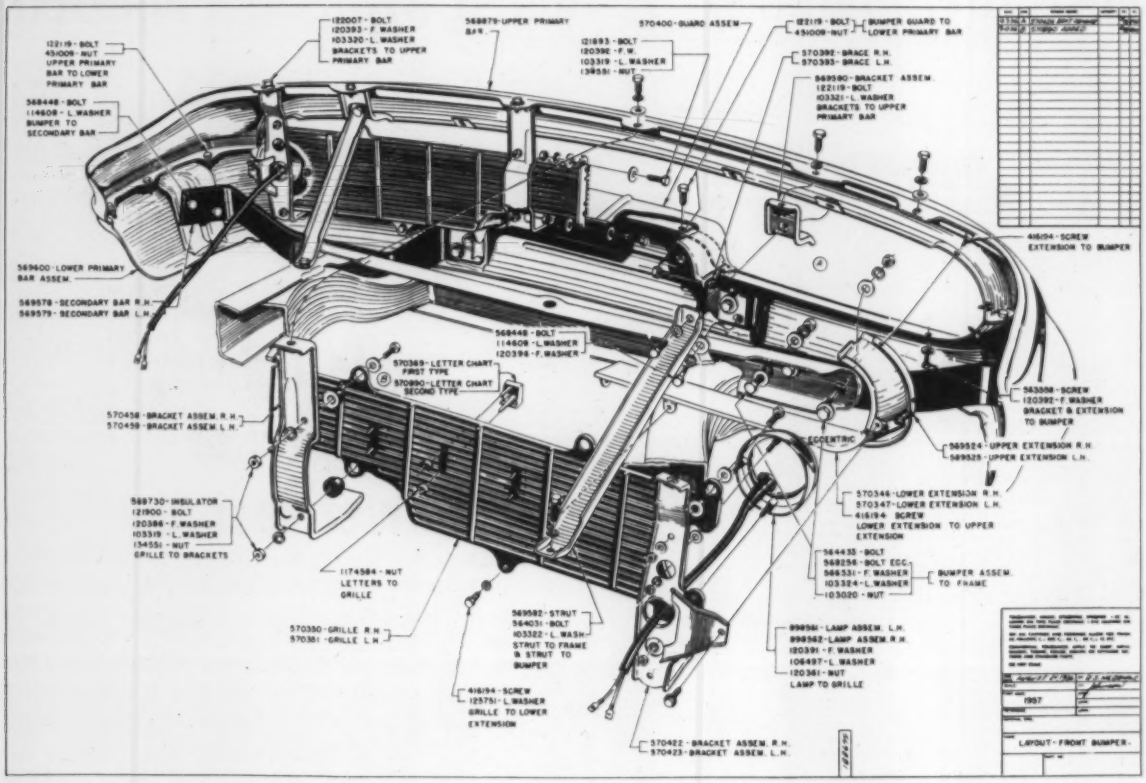

122007 - BOLT
120393 - F. WASHER
103320 - L. WASHER
BRACKETS TO UPPER PRIMARY BAR
568879 - UPPER PRIMARY BAR
570400 - GUARD ASSEM.
122119 - BOLT
451009 - NUT
BUMPER GUARD TO LOWER PRIMARY BAR
121893 - BOLT
120392 - F.W.
103319 - L. WASHER
139581 - NUT
570392 - BRACE R.H.
570393 - BRACE L.H.
569580 - BRACKET ASSEM.
122119 - BOLT
103321 - L. WASHER
BRACKETS TO UPPER PRIMARY BAR
122119 - BOLT
451009 - NUT
UPPER PRIMARY BAR TO LOWER PRIMARY BAR
568448 - BOLT
114608 - L. WASHER
BUMPER TO SECONDARY BAR
569600 - LOWER PRIMARY BAR ASSEM.
569578 - SECONDARY BAR R.H.
569579 - SECONDARY BAR L.H.
416194 - SCREW
EXTENSION TO BUMPER
568448 - BOLT
114608 - L. WASHER
120394 - F. WASHER
570389 - LETTER CHART FIRST TYPE
570390 - LETTER CHART SECOND TYPE
563558 - SCREW
120392 - F. WASHER
BRACKET & EXTENSION TO BUMPER
570458 - BRACKET ASSEM. R.H.
570459 - BRACKET ASSEM. L.H.
ECCENTRIC
569524 - UPPER EXTENSION R.H.
569525 - UPPER EXTENSION L.H.
569730 - INSULATOR
121900 - BOLT
120386 - F. WASHER
103319 - L. WASHER
134551 - NUT
GRILLE TO BRACKETS
570346 - LOWER EXTENSION R.H.
570347 - LOWER EXTENSION L.H.
416194 - SCREW
LOWER EXTENSION TO UPPER EXTENSION
564433 - BOLT
568256 - BOLT EDG.
566531 - F. WASHER
103324 - L. WASHER
103020 - NUT
BUMPER ASSEM. TO FRAME
1174584 - NUT
LETTERS TO GRILLE
569592 - STRUT
564031 - BOLT
103322 - L. WASH-
STRUT TO FRAME & STRUT TO BUMPER
570330 - GRILLE R.H.
570331 - GRILLE L.H.
999561 - LAMP ASSEM. L.H.
999562 - LAMP ASSEM. R.H.
120391 - F. WASHER
106497 - L. WASHER
120361 - NUT
LAMP TO GRILLE
416194 - SCREW
125751 - L. WASHER
GRILLE TO LOWER EXTENSION
570422 - BRACKET ASSEM. R.H.
570423 - BRACKET ASSEM. L.H.
1957
LAYOUT - FRONT BUMPER -

Fig. 1—Example of graphic illustration which can effectively replace orthographic drawings. Item illustrated here is an automobile bumper assembly.

points. Dimensions determine points to be plotted horizontally or vertically. A series of connected points form the lines. Another method of preparing a graphic illustration is to paste a group of related drawings, notes and other data on paper board. The finished layout is photographed and reduced for further processing.

From a paper entitled "Development and Use of Graphic Illustrations in Product Engineering" presented at the SAE Annual Meeting in Detroit, January, 1957.

Controlling Design and Engineering

with data-processing equipment

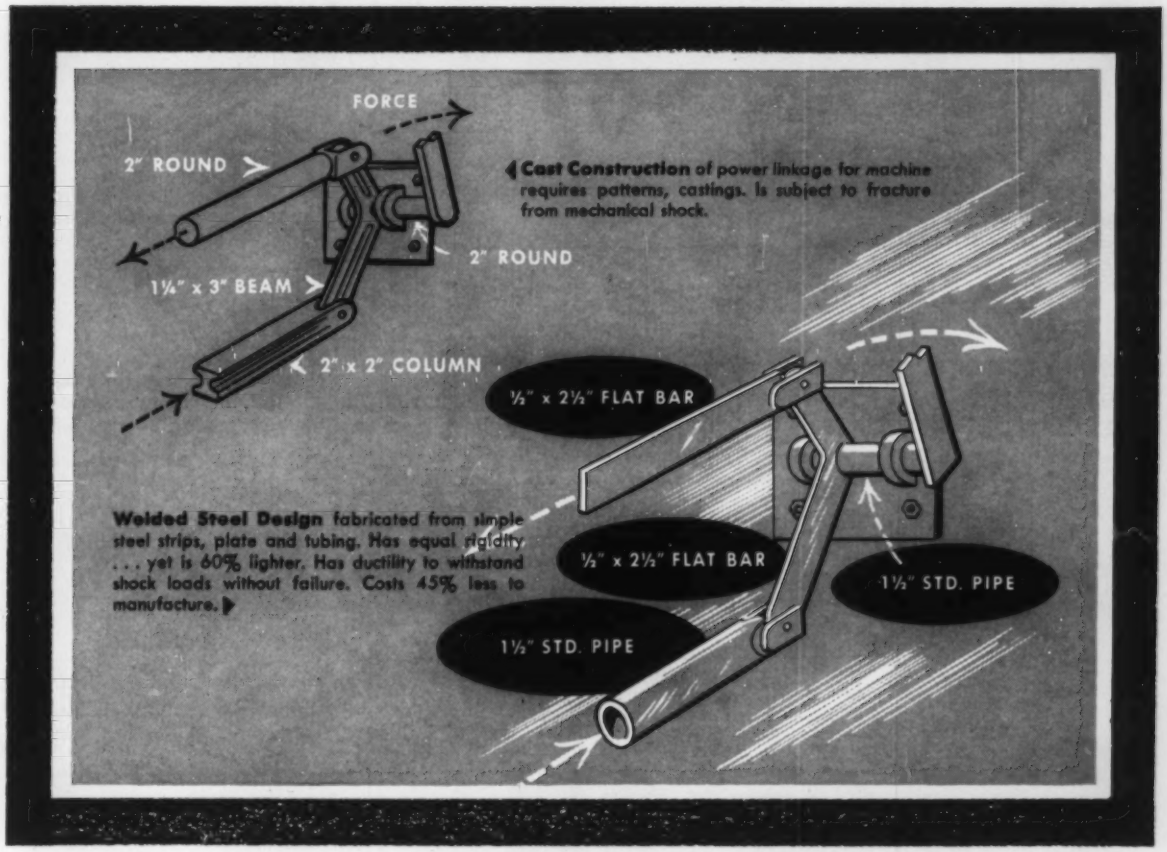
By D. H. Ware, W. J. Martiny and F. J. Maginniss

General Electric Co.
Schenectady, N. Y.

ELECTRONIC data - processing machines (EDPM's) are applicable to nearly all engineering activities and result in more efficient operations and effective management control. They broaden the base for decisions, speed up research and development studies and force standardization of procedures as well as products.

Special Problems: Types of equipment must be chosen which will satisfy the varied requirements of the over-all organization. This means analysis of the capabilities and capacities of many types of machines and an evaluation of their qualities in regard to varied applications.

Another problem involves setting up proper techniques. A good deal of research and study are required, but one of the hidden bene-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1¼" x 3" BEAM
2" x 2" COLUMN
2" ROUND
Cast Construction of power linkage for machine requires patterns, castings. Is subject to fracture from mechanical shock.
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½" x 2½" FLAT BAR
1½" STD. PIPE
1½" STD. PIPE
Welded Steel Design fabricated from simple steel strips, plate and tubing. Has equal rigidity . . . yet is 60% lighter. Has ductility to withstand shock loads without failure. Costs 45% less to manufacture.

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MACHINE DESIGNERS

Write for Weldesign Sheets giving latest ideas in saving material and cost with welded steel.

THE machine linkage shown illustrates how costs can be cut on many types of product designs. Production savings come from lower material costs and from faster, simpler fabrication. The product is also stronger, more dependable in service since weight and inertia forces are lower. Modifications in design to suit customers' special needs are simpler too, because patterns and castings are no longer required.

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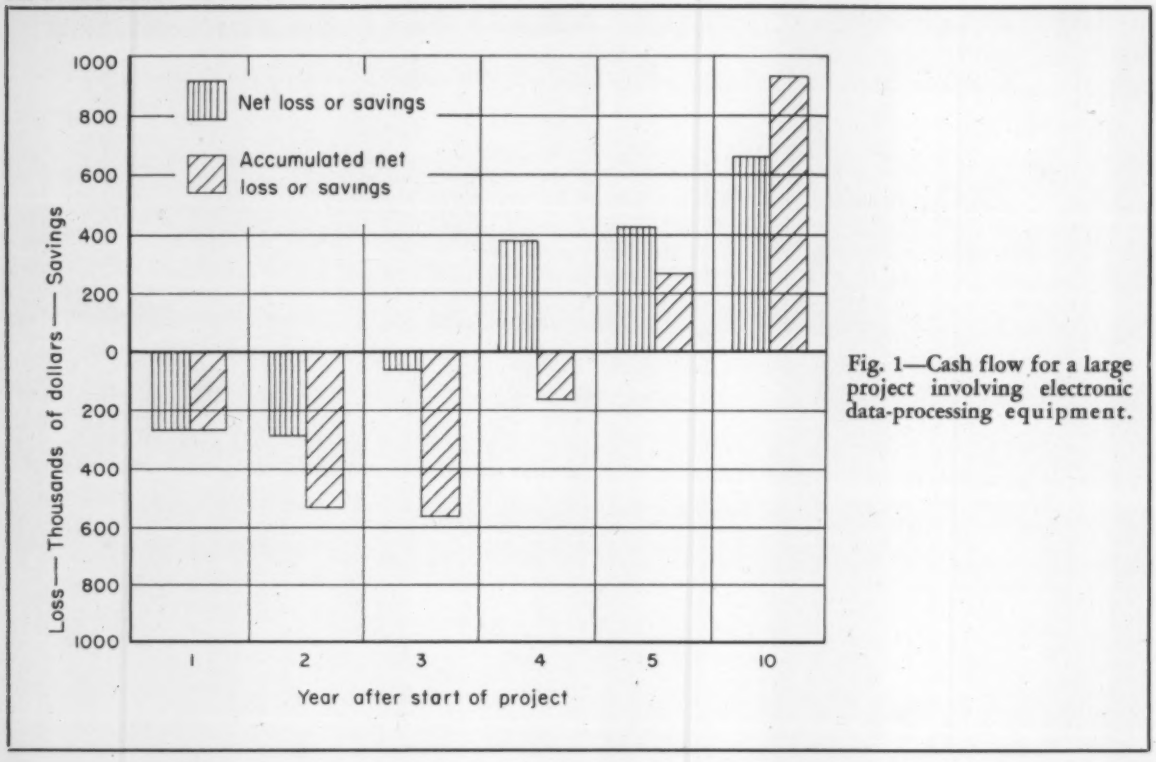


Fig. 1—Cash flow for a large project involving electronic data-processing equipment.

fits of a thorough analysis of methods is the savings in dollars, Fig. 1, which are made possible by improvements in methods.

Most important of the problems, and one which must predate the other two, is the training of personnel. Engineering management which intends to benefit from EDPM's must provide some organized training course for a number of employees, including key personnel who will be closely associated with and responsible for the application of the machines.

Control of Engineering Decisions: Effective control through EDPM can be realized by:

1. Removing restrictive assumptions and setting up realistic mathematical models of the product which lead to closer prediction of actual product performance and build confidence in calculations.
2. Investigating specific designs in greater detail than was formerly feasible.
3. Standardizing calculation approach so that comparisons of results are valid on a broader base.
4. Controlling standardization of parts where combinations of parts are selected from a predetermined program rather than manually.
5. Bringing complex calculations to the command of less experienced engineers.
6. Reducing drudgery for engineers and improving the climate for creative work.

Research and Development: Electronic data-processing machines afford the opportunity to make a detailed mathematical analysis before entering into the model-building phase. This permits faster completion of the project and more significant information from tests. It increases the breadth of the investigation and provides more background information for decision-making.

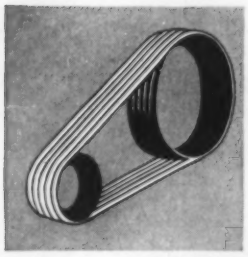
Results of development studies are made available to the entire organization by these machines. By programming the analysis of a complex problem, it becomes possible to calculate the results without an extensive study of written material.

In many cases a shortage of engineering manpower may compel the use of EDPM's to extend competent decision-making to less experienced engineers without sacrificing freedom of action, yet maintain assurance of satisfactory performance.

Engineering and Manufacturing: A certain amount of inventory control through electronic data-processing machines can be achieved by cross-checking programs. The EDPM has the attendant advantages of being able to feed back to engineering management reports on the types of specialties which are being sold or products or parts being built in sufficient quantities to justify standardization or extra design effort to reduce variety.

One of the most important advantages from the use of EDPM's for generating engineering documents is that it permits more widespread and effective use of these machines to increase efficiency of data processing in all management functions dependent upon these documents.

From a paper entitled "Control of Design and Engineering Procedures Through Electronic Data-Processing Equipment" presented at the ASME Engineering Management Conference in Pittsburgh, March, 1957.



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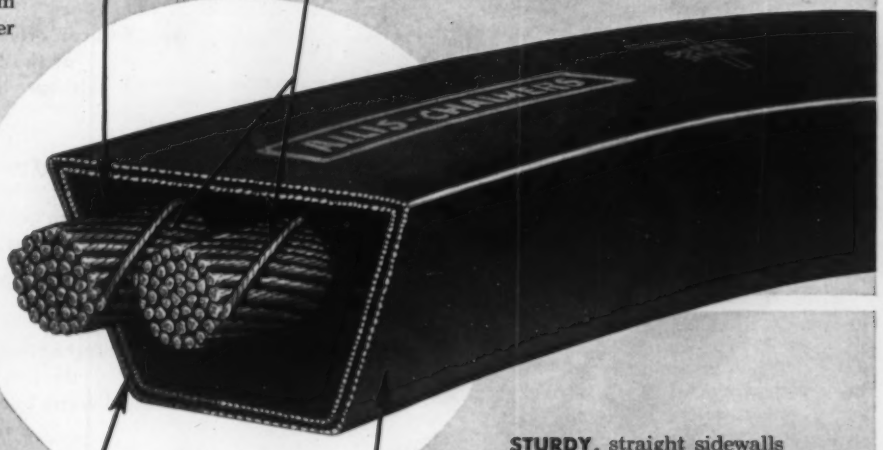
EXTRA STRONG, heavy twin grommets each offer more than enough tensile strength to handle any load normally encountered. They're precisely located to assure uniform load distribution.



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STURDY, straight sidewalls guarantee maximum gripping power. Tendency to bulge is converted into gripping sidewall pressure because cast-iron sheave sidewalls confine the belt.

Texrope is an Allis-Chalmers trademark.

For More Information on *Texrope* belts, sheaves and other mechanical power transmission equipment, contact your nearby Allis-Chalmers distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5269

for smooth power

. . . CONE-DRIVE gearing has no equal.

You can drive the most delicate equipment or the heaviest industrial machinery without vibration or noise through a set of Cone-Drive gears.

Smooth delivery of power is an outstanding feature of Cone-Drive double-enveloping worm gearing. It's the result of a unique design that puts one-eighth of all gear teeth in simultaneous, full-depth contact with the worm threads.

The contact between teeth is "area" rather than the line or point type contact found in cylindrical worm gearing. This distributes the load over more area on each tooth to boost load-carrying capacity.

Want smooth, chatter-free, efficient power in a compact package? Cone-Drive gears will give it to you in gearsets or speed reducers in a wide range of models and sizes.

Ask for Bulletin 600-C for details.

CONE-DRIVE GEARS
Division, Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN

Circle 487 on page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Production Facilities

Facilities for screw machine work, hot and cold upsetting and various secondary operations are outlined in brochure "Under One Roof at Chicago Screw." Capacities of all equipment are given, and heat treating, cleaning and coating processes are listed. 8 pages. Chicago Screw Co.

Circle 680 on page 19

Drafting Machines

Features of the new Boardmaster drafting machine are pointed up in brochure. This device can be readily adapted to horizontal, sloping or vertical drafting boards. Specifications are given and accessories are described. 8 pages. Universal Drafting Machine Co.

Circle 681 on page 19

Stud Welding Manual

This "Design Manual" features tips on how to take full advantage of savings inherent with stud welding. It describes physical properties of stud types and discusses stud selection, counterbore and countersink dimensions, steel thicknesses and stud locating. 24 pages. Gregory Industries, Inc., Nelson Stud Welding Div.

Circle 682 on page 19

Die Casting Technology

Comprehensive technical brochure on modern die casting technology describes this method's design characteristics and mass-production advantages. Sections cover die-making and permanent mold castings. Quality control is also reviewed. 8 pages. Harvill Corp.

Circle 683 on page 19

Conveyor Pulleys

Bulletin 5781 covers welded steel conveyor pulleys for belt conveyor and bucket elevator systems. Drum types and the self-cleaning wing-type pulleys are included. 6 pages. Chain Belt Co.

Circle 684 on page 19

Pinch-Type Valves

Catalog FL-1116 on Flex pinch-type valves for abrasives, corrosives, slurries and foods has a comprehensive data section which covers sizing, capacities, flow characteristics, operating air pressures, installation and maintenance, and corrosion resistance. Flexible, pinch-type and hose-bodied valves are covered. 48 pages. Farris Flexible Valve Corp.

Circle 685 on page 19

Electric Thermostat

Model E1 single-throw reverse-acting thermostat for refrigerating, ventilating and alarm systems closes on a rising temperature. It is offered in temperature ranges up to 800°F. Bulletin RT-804 has installation and data. 4 pages. Robertshaw-Fulton Controls Co.

Circle 686 on page 19

Marine Hoses & Fittings

Catalog 301 on flexible piping for marine applications includes planning information, bend radii data, pressure and vacuum data and other pertinent engineering information. Specs cover hose and fittings for use with diesel fuel, lube oil, hydraulic fluid, LP-gas, Freon 12, steam, and salt, fresh and drinking water lines. 54 pages. Aeroquip Corp.

Circle 687 on page 19

Special Wing Nuts

Price list 4H and supplementary stock sheet No. 3 list specifications of high, round, low and special low wing nuts with washer type bases. 1 page each. Gries Reproducer Corp.

Circle 688 on page 19

Slow Motion Worm Motor

Economy advantages of the Brevel slow motion worm motor are outlined in data sheet WM 450. Motor is used to power small electric appliances, vending machines, motion displays, turntables and other mechanical devices. Standard specifications are listed. 2 pages. Brevel Products Corp.

Circle 689 on page 19

Small Metal Parts

One of the largest assortments of standard lugs, clips, terminals and wire forms is listed in stock catalog No. 21. Designer's sketchbook section shows standard parts with thumbnail detail drawings. Parts are grouped according to the most common use. 44 pages. Zierick Mfg. Corp.

Circle 690 on page 19

High Speed Cameras

Technical data on Kodak high speed motion picture cameras and film for use in them are found in illustrated bulletin Fl-2. Action is slowed down up to 200 times. Several case histories are presented. 12 pages. Eastman Kodak Co.

Circle 691 on page 19

Timing Motors

Function of three basic direct-current timing motors and their construction and operation are covered in bulletin AWH MO 805. Described are 4½ to 30 v general duty, electronic circuits and Roto-Tork Series is for use as a rotary actuator. 2 pages. A. W. Haydon Co.

Circle 692 on page 19

Copper-Clad Plastic Laminate

What printed circuits are, advantages resulting from their use and the construction and properties of copper-clad Micarta plastic laminate for printed circuits are covered in illustrated booklet B-6577. 8 pages. Westinghouse Electric Corp.

Circle 693 on page 19

Speed Reducers

Details on an improved line of Cone-Drive double-enveloping worm gear speed reducers are presented in illustrated bulletin CD-218. Stocked units have capacities up to 665 hp, ratios from 5:1 to 70:1, and center distances from 2 to 18 in. in extended shaft and shaft-mounted types. Engineering data are given. 24 pages. Michigan Tool Co., Cone-Drive Gears Div.

Circle 694 on page 19

Springs

How manufacturing standards, price and quotation methods, refusals to quote, realistic spring tolerances, types of spring ends, finishes and packaging considerations affect spring cost are related in illustrated "Spring Buyer's Guide." Conventional and special spring products,

equipment and facilities of company are also covered. 12 pages. Hunter Spring Co.

Circle 695 on page 19

Gas Pressure Regulators

Various types of cylinder, manifold and pipeline pressure regulators for industrial compressed gases are detailed in illustrated catalog 806. Single and two-stage units are covered, along with laboratory and metering regulators and gas proportioners. 40 pages. Air Reduction Co.

Circle 696 on page 19

Motors, Fans & Blowers

Synchronous, torque, induction and gear motors; centrifugal blowers; and axial fans are subject of illustrated catalog 83. Standard and custom units are suited for commercial and military applications. Specifications are given. 12 pages. Ashland Electric Products, Inc.

Circle 697 on page 19

Electrical Connectors

Miniature hermetic, quick disconnect, push-pull, rack and panel, and Edgelite panel electrical connectors are described and illustrated and their operating features are given in catalog. Drawings of each unit and other engnieering data are included. 24 pages. Deutsch Co.

Circle 698 on page 19

Cold Drawn Tubing

Uniform physical properties, exact tolerances and good surface qualities are features of cold drawn Electric-weld tubing, subject of illustrated folder. Various strengths, tolerances and finishes are available. 4 pages. Jones & Laughlin Steel Corp.

Circle 699 on page 19

Air Compressors

Construction features, selection aids and specifications for line of air compressors are found in illustrated catalog C-50. Single and two-stage units with ½ to 15-hp ratings for pressures to 150 psi are covered. Drives are electric and gasoline engine. 20 pages. DeVilbiss Co.

Circle 700 on page 19

Bobbins

Standard and special textile, electrical manufacturing and metalworking industry bobbins made of vulcanized fiber, Phenolite laminated plastic, maple, steel, aluminum and special alloys are described and illustrated in catalog "Lestershire Bobbins." Sixteen examples of five basic types are shown. 12 pages. National Vulcanized Fibre Co., Lestershire Spool Div.

Circle 701 on page 19

Plastic Cushioned Clamps

Engineering handbook on Teflon tetrafluoroethylene covers its application as a cushioning and insulating material for supporting clamps. Chemical, thermal, electrical and ageing properties and handling methods are given. Seven clamp models are offered in 18 types. 20 pages. TA Mfg. Corp.

Circle 702 on page 19

Aircraft Equipment

Alternating and direct current generators, voltage and exciter regulators, control panels, transformers, relays, protective panels, circuit breakers, inverters, converters, turbojet and reciprocating engine starters, and special ac and dc motors are among aircraft equipment described and illustrated in catalog 6023. 12 pages. Jack & Heintz, Inc.

Circle 703 on page 19

Small Motors & Blowers

Permanent split capacitor, shaded pole and series or shunt types of subfractional horsepower electric motors are described in "MicroMotor" catalog RB-400. Design and performance data are included on small single and double motor driven blowers as well as on special electric products. 12 pages. Redmond Co.

Circle 704 on page 19

Stainless Steel

"Stainless Steel in Product Design" is an illustrated brochure that contains compositions, application data and technical information on the various stainless steels. Many practical examples of its use and places where its advantages stand out are detailed. Wide variety of end products is shown in this AISI-sponsored brochure. 40 pages. Allegheny Ludlum Steel Corp.

Circle 705 on page 19

Die-Cast & Plastic Parts

All 67 different types of zinc alloy die-cast and thermoplastic parts are listed in "Service & Products" bulletin. Details are given on Intercast products with movable elements as well as such products as plastic and zinc gears and pinions, coil bobbins, insert castings and precision fasteners. 8 pages. Gries Reproducer Corp.

Circle 706 on page 19

Speed Reducers

Helical gear speed reducers in thermal horsepower ratings from 11 to 187 are subject of illustrated design manual. AGMA ratings are tabulated and typical applications of speed reducers are shown. 14 pages. Alten Foundry & Machine Works, Inc.

Circle 707 on page 19

Powdered Metal Parts

How to save money through the use of Remet powdered metal parts is explained in illustrated data sheet. Physical characteristics of various materials and typical parts made to specification are shown. 2 pages. Reese Metal Products Corp.

Circle 708 on page 19

Motor Starters

Made in all types through size 3, type CY starters for alternating current motors are offered in general purpose, water-tight, dust-tight and explosion - resisting NEMA enclosures. Design features of these controls are shown in illustrated bulletin. 8 pages. Clark Controller Co.

Circle 709 on page 19

Aluminum Fasteners & Parts

"Alcoa Aluminum Fasteners and Screw Machine Products" is title of illustrated manual on screws, bolts, nuts, rivets, washers, nails, pipe plugs and special parts carried in stock and made to order. Available sizes are tabulated and typical parts are shown in bulletin AD-244. Sales offices and local distributors are listed. 8 pages. Aluminum Co. of America.

Circle 710 on page 19

Electric Heaters

Two illustrated bulletins, F1566 and 850, describe Chromolox electric strip heaters and electric cartridge heaters, respectively. In addition to showing design details of these heaters, typical applications for spot or overall heating are shown. 4 pages each. Edwin L. Wiegand Co.

Circle 711 on page 19

Roof Ventilators

Performance data, construction details and dimensions on a complete line of centrifugal roof ventilators

Circle 488 on page 19→

IN TRANSPORTATION EQUIPMENT, TOO

Sharonsteel Quality

STANDS OUT

The quality standards and specifications of the transportation equipment manufacturers are known to be among the most exacting in American industry.

For this reason, many leading suppliers of automotive bus, truck and trailer chassies; railway cars, trucks, underframes and the exciting new air spring suspension (foreground) depend on Sharon Steel for high strength, low alloy strip and plate used in their products.

Other types of steel selected by the industry for their high quality are Sharon's line of stainless, coated and alloy strip and plate.

SHARONSTEEL

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253

SHARON STEEL CORPORATION, SHARON, PENNA.

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THERE MUST BE AN EASIER WAY

—AND THERE IS WITH . . .

MIDLAND

WELDING NUTS

The Midland Steel Products Company is constantly developing new, progressive ideas to improve the efficiency of its fine products. It pioneered the *Midland Welding Nut,* for example, and so successful was this application in its own shops that this labor-saving device has been made available to others.

If you are a manufacturer of metal parts or products and have fastening, fabricating or assembling problems, you may find Midland Welding Nuts just the solution you've been looking for. The Nuts are easily welded into position for the lifetime of the product. You can be assured of correct fit, even in the most awkward, hard-to-reach places. Bolts turn easily into the applied nuts. Thus, heretofore two-man operations can be handled by one man in most instances. Weld-nut equipped parts will be preferred by your customers for they will find them cost-saving and trouble-free, cutting down assembly time. Too, you can be sure that your parts will be properly assembled without the risk of rattles.

A few minutes' time in checking the assembly problems of your customers will be profitable to you. Midland Welding Nuts are low in cost, can give you a definite advantage over competition. This practical application is recognized internationally and endorsed by many designers of the finest products.

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Avenue • Detroit 11, Michigan

Export Department: 38 Pearl St., New York, N. Y.

Automobile and Truck Frames • Air and Vacuum Power Brakes

Air and Electro-Pneumatic Door Controls

Helpful Literature

for industrial plants are presented in illustrated bulletin SDA-220. Capacities range up to 19,686 cfm free air delivery. 8 pages. Peerless Electric Co., Fan & Blower Div.

Circle 712 on page 19

Boron Stainless Steel

Containing 1 per cent boron, a new wrought austenitic alloy is offered in plate, sheet, strip and bars. It is workable hot and cold, weldable, machinable and corrosion resistant. Complete properties and design information on this stainless steel are given in bulletin 57. 8 pages. Superior Steel Corp.

Circle 713 on page 19

Graphite Products

Information on graphite crucibles, boats and molds as well as on treated carbon and graphite products are contained in two data sheets. 2 pages each. Speer Carbon Co.

Circle 714 on page 19

Rotary Pumps

"How Industry Profits with Viking Pumps" is title of illustrated application manual which shows uses of Viking pumps for handling various products such as paint, chemicals, resins, petroleum products, tars, foods and solvents. Both custom built and standard models are available. 8 pages. Viking Pump Co.

Circle 715 on page 19

Stock Rubber Parts

Grommets, bumpers, bushings and crutch tips are typical of standard rubber products carried in stock by this company. Supplement to engineering catalog No. 100 lists dimensions of these parts in various hardnesses. 4 pages. Continental Rubber Works.

Circle 716 on page 19

Die Cast Alloys

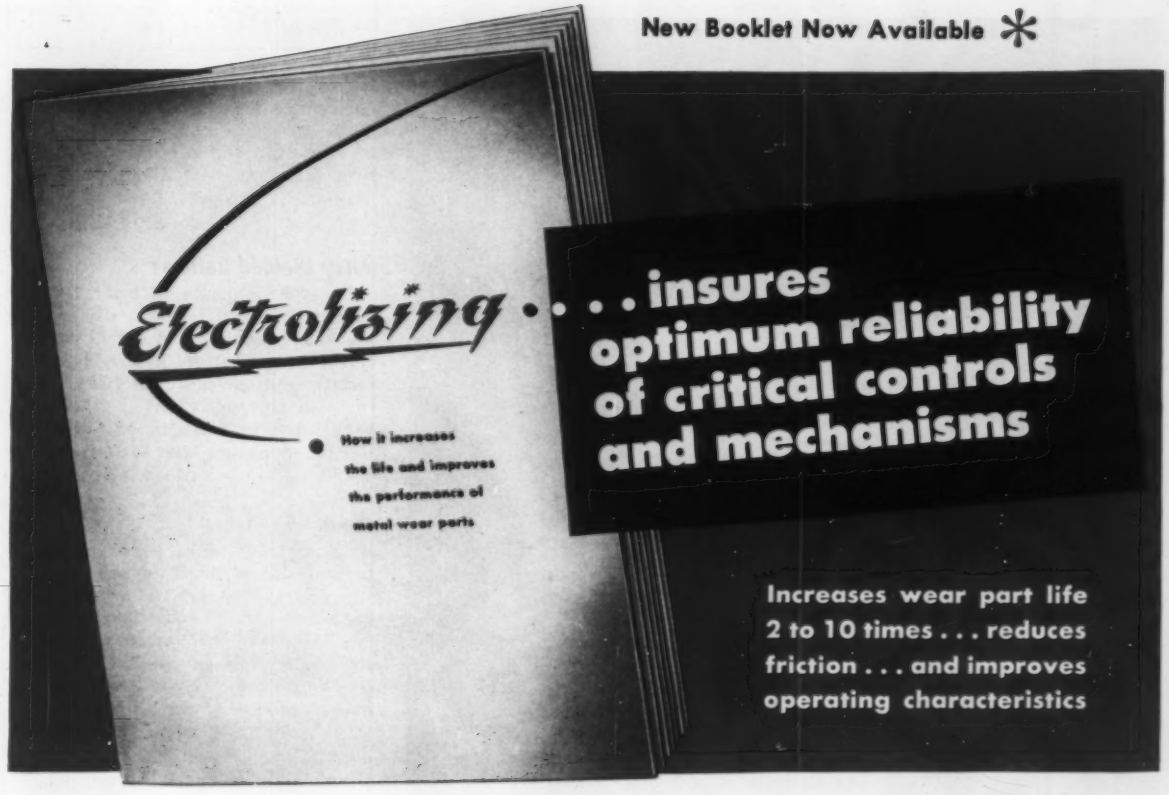
Loose leaf guide entitled "Engineering Data for Die Casting Alloys" helps make more effective use of the design, material and cost-saving advantages of die cast component parts. It provides specifications, tolerance tables and physical properties. 36 pages. Parker White Metal Co.

Circle 717 on page 19

Speed Reducers

Complete design and engineering data on single and double reduction worm gear, double reduction worm and helical gear, single reduction

New Booklet Now Available *


Electrolizing
How it increases the life and improves the performance of metal wear parts
. . . insures optimum reliability of critical controls and mechanisms
Increases wear part life 2 to 10 times . . . reduces friction . . . and improves operating characteristics

How Electrolizing Insures Reliability:

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The new 24-page booklet illustrated explains how Electrolizing insures reliability of equipment . . . how it increases wear life of ferrous and non-ferrous parts 2 to 10 times—without change in design, materials or methods.

Electrolizing provides high surface hardness, low co-efficient of friction and excellent anti-seizure properties. There is no warping, distortion or other adverse effect on the basis metal—no embrittlement. Tolerances can be held within .000025″ . . . original surface finish is retained . . . no edge build-up is encountered.

The booklet answers nearly every question you might ask—includes a complete technical discussion . . . contains numerous test reports on military and commercial applications . . . points the way to achieving reliability that is otherwise impossible or impractical to attain.

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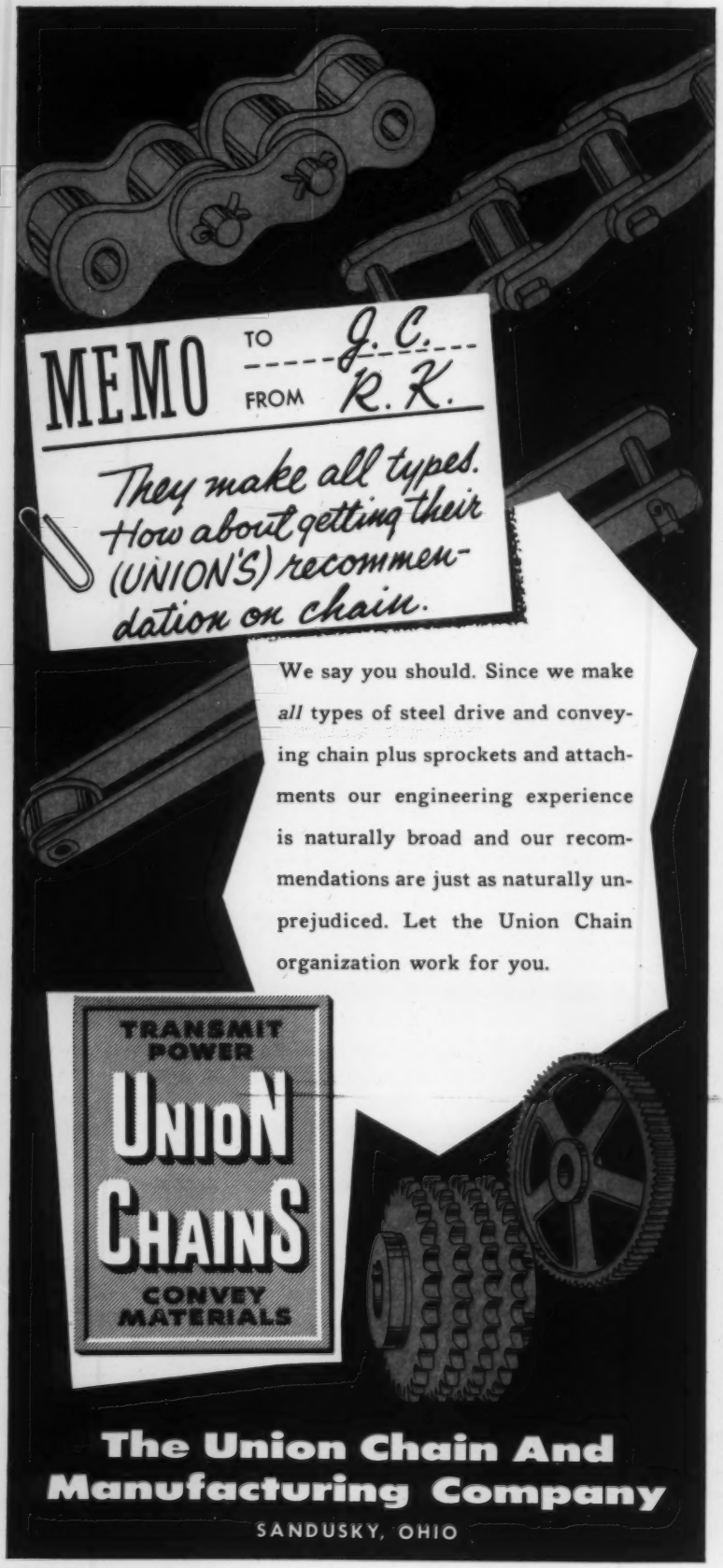

MEMO TO J. C.
FROM R. K.
They make all types. How about getting their (UNION'S) recommendation on chain.
We say you should. Since we make all types of steel drive and conveying chain plus sprockets and attachments our engineering experience is naturally broad and our recommendations are just as naturally unprejudiced. Let the Union Chain organization work for you.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

Helpful Literature

helical gear, two speed reduction and differential speed reducers are contained in comprehensive catalog 155. Sectionalized and fully indexed, this is a complete manual on speed reducers. 110 pages. Winsmith, Inc.

Circle 718 on page 19

Alloy Welded Bellows

General discussion of basic Belfab "precisioneered" bellows design is given in catalog 2 and covers spring rated, life, pressure, hysteresis, materials and physical properties of common bellows materials. Bellows have extension-compression ratios up to 6:1. 8 pages. Belfab Corp.

Circle 719 on page 19

Plastic Products

"Nosco Plastics" is a pictorial presentation of this company's facilities and typical products which are engineered and produced to customer's specifications. Case histories show cost savings possible through Nosco service. 12 pages. Nosco Plastics, Inc.

Circle 720 on page 19

Diaphragm Valves

Exclusive features of diaphragm valves for positive closure, and plastic valves and diaphragms for corrosive services are pointed up in catalog 104. Specifications of several models and a reference chart for material selection are included. 12 pages. Hills-McCanna Co.

Circle 721 on page 19

Resistance Welded Products

Laboratory Bulletin SP-18 on resistance weld production includes photos and descriptions of over 300 different products mass-produced by resistance welding. Spot, projection, flash-butt, upset-butt and seam welding, and electroforging are covered. 24 pages. Taylor-Winfield Corp.

Circle 722 on page 19

Zirconium Tubing

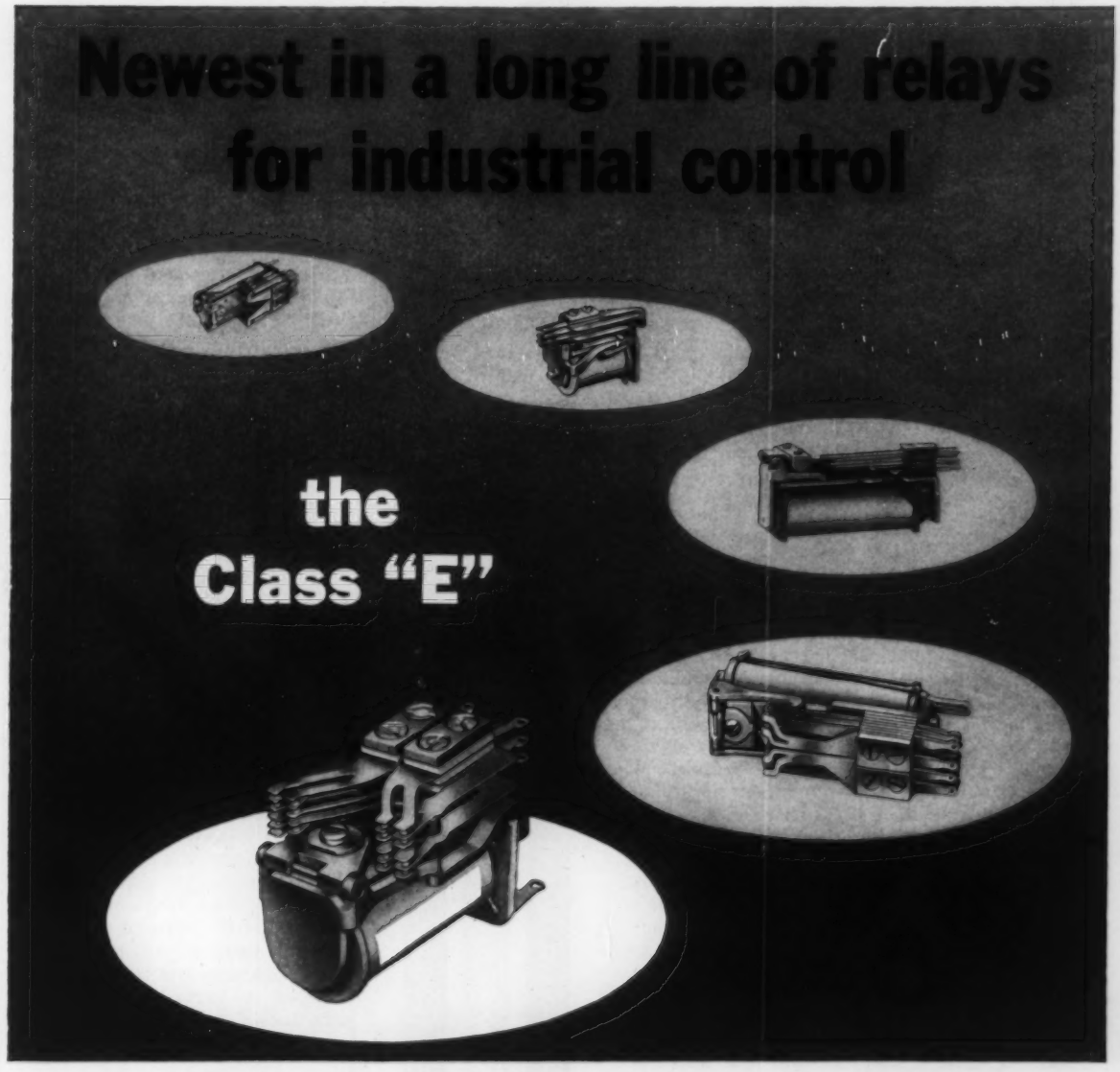
Physical properties of zirconium and the Zircaloys are presented in Special Analysis Memorandum No. 112. Mechanical properties of fully annealed, half-hard drawn and full-hard drawn tubing tempers are given. 4 pages. Superior Tube Co.

Circle 723 on page 19

Metal Hose & Bellows

Applications of flexible metal hose and bellows are described in catalog 156 which also presents engineering

Newest in a long line of relays for industrial control



This is the relay you've asked us to build. Now Automatic Electric is happy to present its latest achievement—the miniature Class "E". We're proud because this husky baby brother of the Class "B" condenses all of its famous features in a minimum of space and weight . . . with no sacrifice of quality! Many Class "E" features appear for the first time in a relay of such compact size. Here's a relay which is indispensable where small size and weight (coupled with reliable performance) are of prime importance.

This new miniature relay comes to you with a solid reputation, backed by 65 years of leadership in automatic dial telephone equipment for America's Independent telephone companies and leadership in industrial controls for industry.

Check these features of the new Class "E"—

- miniaturized, telephone-style, base mounting for rear-connected wiring.
- heavy thickness armature arms (previously available only in larger relays).
- heavy-duty backstop that won't wear out.
- adequate terminal clearances for easy wiring.
- long-life, lubricant-retaining bearing also allows for an easy check of the heelpiece airline setting, without disturbing the adjustment.
- fully independent twin contact springs.
- sturdy, strain-relieved heelpiece insures stability of adjustment.

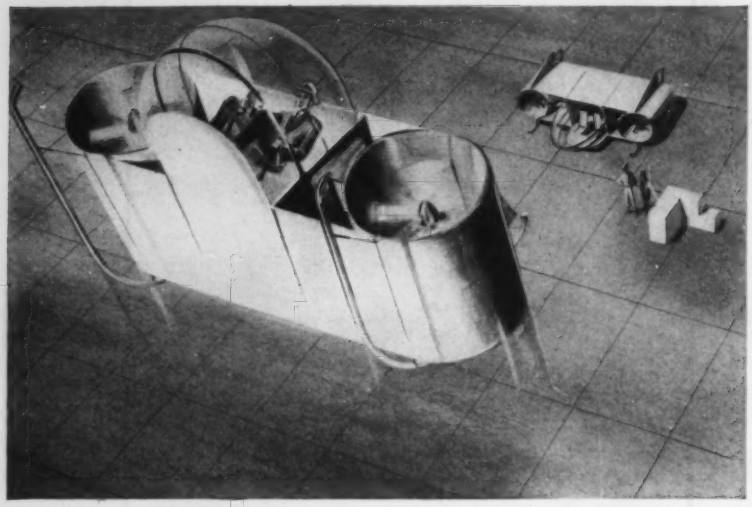
For more information, call or write Automatic Electric Sales Corporation, Chicago 7. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

AUTOMATIC ELECTRIC

A MEMBER OF THE GENERAL TELEPHONE SYSTEM

ONE OF AMERICA'S GREAT COMMUNICATIONS SYSTEMS

MARS outstanding design **SERIES**



rock 'n' fly

A design combining the aerodynamic principles of ring wings, ducted propulsion and elevons is the novel concept for this all-purpose utility plane that "rocks" on take-off and landing.

Resting on the ground horizontally, the plane is rocked back into vertical take-off position with partial power. It lands the same way, backing down to the ground, then forward to rest. Designer M. A. Novosel of Van Nuys also suggests a unique provision: if one engine fails, an inter-engine shaft is automatically coupled to maintain even thrust. But, most of all, this imaginative "aerial pickup" design embodies economy of operation in both fuel and space.

No one can be sure which of today's design ideas will become production realities tomorrow. But it will be as important then, as it is now, to use the best of tools when pencil and paper translate an idea into a project. And then, as now, there will be no finer tool than Mars – from sketch to working drawing.

Mars has long been the standard of professionals. To the famous line of Mars-Technico push-button holders and leads, Mars-Lumograph pencils, and Tradition-Aquarell painting pencils, have recently been added these new products: the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman's" Pencil Sharpener with the adjustable point-length feature; and – last but not least – the Mars-Lumochrom, the new *color-drafting* pencil which offers revolutionary drafting advantages. The fact that it blueprints perfectly is just one of its many important features.

The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom colored *drafting* pencil, 24 colors.

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

at all good engineering and drawing material suppliers

Helpful Literature

specifications and sizes, pressure ratings, materials and fitting attachments. Hose is made in corrugated and convoluted styles. 16 pages. Flexonics Corp.

Circle 724 on page 19

Motors

Stock list of motors includes 1/6-7½ hp repulsion induction totally-enclosed units, ¾-1½-hp adjustable speed motor systems, ¼-20 hp squirrel cage induction polyphase enclosed motors, 1/6-1 hp explosionproof motors, 1/30-¾ hp capacitor run motors and rerated frames. 4 pages. Baldor Electric Co.

Circle 725 on page 19

Thermistors

Listing typical applications and circuitry, catalog T-100 gives specifications and characteristics of wafer, rod and bead thermistors. Table showing the resistance ratio versus temperature is provided to compute thermistor resistance at specified temperatures. 10 pages. Gulton Industries, Inc., Thermistor Div.

Circle 726 on page 19

Contact Meter-Relays

Contact meter-relays that both indicate and control almost any physical or chemical condition that can be detected electrically are described in catalog 4-C. Different control circuits are discussed. API panel meters and auxiliary control components are included. 40 pages. Assembly Products, Inc.

Circle 727 on page 19

Bimetal Thermostats

Both hermetically sealed and semi-enclosed snap-acting type M bimetal thermostats are described as to operation construction, features and ratings in bulletin 6000. Terminal arrangements are pictured. 2 pages. Stevens Mfg. Co.

Circle 728 on page 19

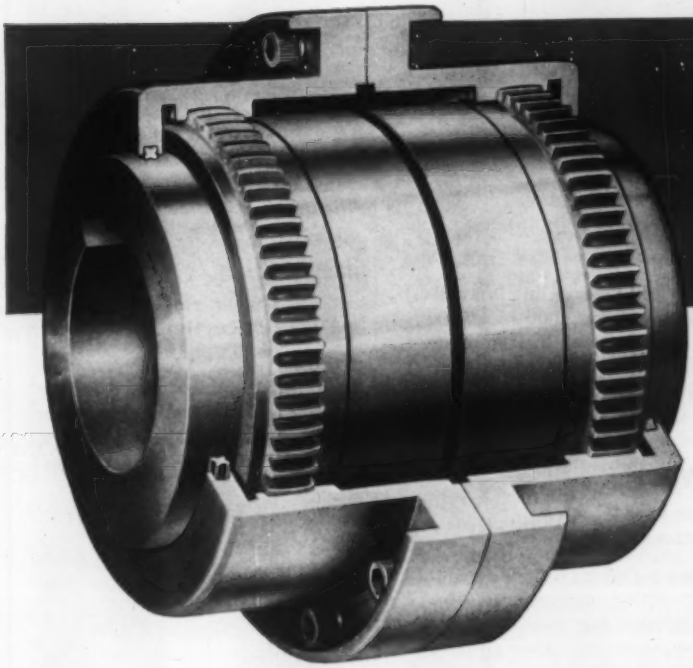
V-Drives

Descriptions and size data on extensive line of bushed and fixed bore cast iron and pressed steel V-pulleys, V-belts, refrigeration fans, fan pulleys and V-drive accessories are found in illustrated form F-10. Range is fractional to 10 hp. Interchangeable bushings and multiple V-drives are also covered. 44 pages. Request on company letterhead from Maurey Mfg. Corp., 2915 S. Wabash Ave., Chicago 16, Ill.

Circle 493 on page 19

Why LINK-BELT geared flexible couplings can

transmit more hp per coupling dollar



Size for size, they accommodate larger shafts . . . transmit more power than other comparable couplings

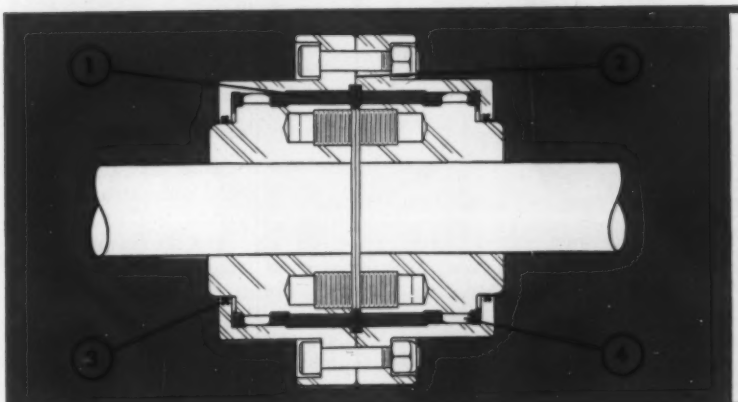
LINK-BELT geared flexible couplings offer an ideal combination of compactness, performance and low cost. They're designed for high load capacity, yet cost less because they are smaller.

Hardened steel socket head flange bolts —ground for close fit—are the key to compactness. They permit a smaller flange. Thus, more of the coupling diameter is devoted to the gear and a larger hub which can be bored to accommodate larger shafts.

In a great variety of coupling applications—including those where shock, vibration, reversing loads and misalignment are encountered—these couplings can be used effectively to assure long life and minimum maintenance. Popular sizes are available with finished bores, packaged and ready for installation. For complete details, contact your nearby Link-Belt office. Or write for your copy of Folder 2775.

LINK-BELT

GEARED FLEXIBLE COUPLINGS



2-piece housing design assures efficient sealing and lubrication

1. In operation, the lubricant centrifuges to the working gear surfaces at the perimeter of inside cavity.
2. Fiber gasket fits tightly between flanges. Lubricant can't escape.
3. Hub seal is smaller in diameter than gear teeth and running level of lubricant. No leakage is possible—dirt and water stay out.
4. Mating gear teeth are constantly lubricated, preventing wear and providing long, trouble-free operation.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,484-A

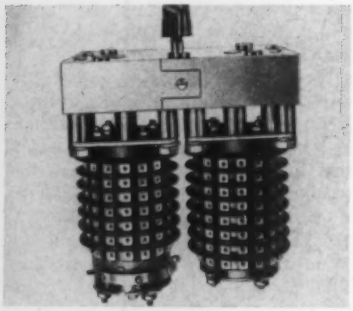
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Rotary Switch Assembly

doubles number of circuits controlled

Gear-operated pair of 16-position, 12-section Type HT rotary multipole switches doubles the number of electrical circuits that can be controlled by a single knob. As-



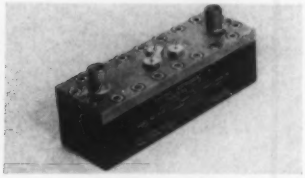
sembly keeps switch length to a minimum and assures positive positioning of rotors at each 22½-deg angle of rotation of the switch handle. Electrical rating (interrupting) is 5 amp, 125 v ac at 0.80 power factor. Assembly has 16 handle positions, 15 "on" and one "off." **Electro Switch Corp.**, Weymouth 88, Mass.

Circle 729 on page 19

Pressure Transducer

for airborne service

Model H pressure transducer operates accurately under vibrations to ±20 *g* and temperatures to 400 F. Designed primarily for airborne service, the instrument incorporates stainless-steel sensing elements which permit the use of corrosive fluids in either gage or differential models. Case and fitting configuration permits stacked arrangements for compact mounting and easy access to pressure and electrical connectors. Case burst



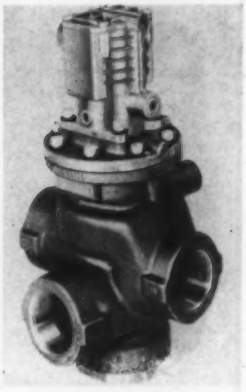
pressure is 7500 psi. Unit is available in ranges from 1000 to 10,000 psig or psid. **Servonic Instruments Inc.**, 1145 S. Fair Oaks Ave., Pasadena, Calif.

Circle 730 on page 19

Control Valves

for high-speed applications

High-Speed Inline high-flow capacity, instant-action, poppet-type control valves are for use on large brakes, clutches and other devices on high-speed applications. The



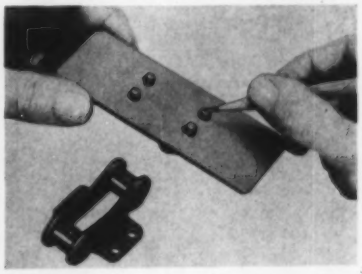
two and three-way valves have three moving parts. Cast Navy M bronze valve bodies, stainless-steel moving parts and Hycar sealing materials afford good resistance to corrosion. Valves are available with integral pilots or for remote pilot operation. Working pressures range from 10 to 200 psi; NPT sizes are 1, 1¼ and 1½ in. Valves are also offered in ¼ to 1 in. NPT sizes, with standard solenoid pilots. **Valvair Corp.**, 454 Morgan Ave., Akron 11, O.

Circle 731 on page 19

Conveyor Chain

has good wear resistance and high strength

Flat-top Ny-Steel conveyor chain has Nylon top plates assembled on either heat-treated carbon steel or stainless-steel chain. Unit is long lasting, retains pitch under mois-



ture conditons, is shock absorbent, resists chemicals and corrosion, and is light in weight. **Link-Belt Co.**, Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 732 on page 19

Metal Finishes

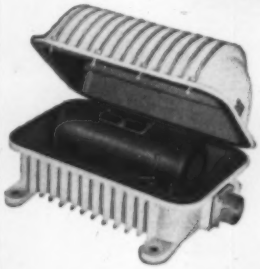
provide protective coatings

Four new finishes include Iridite 5-P, a powdered concentrate which produces a yellow, iridescent coating on zinc and cadmium plate, galvanized iron and zinc die castings. Finish is highly corrosion-resistant, also is a good base for paint. Iridite 8-4, an all-purpose liquid chromate for all forms of zinc and cadmium, provides a bright finish and highly protective coating. Iridite 12-P is a powdered material which provides a one-dip,

Call on *Redmond* to Design, Develop, and Produce Rotating Electrical Mechanisms

ALTERDYN

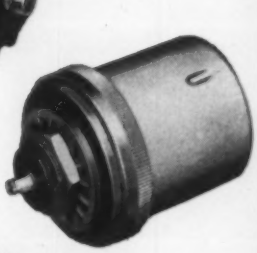
DYNAMOTOR



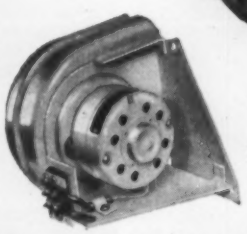
INVERTER

RADAR DEFLECTION YOKE

GYROMOTOR



HAND RING GENERATOR



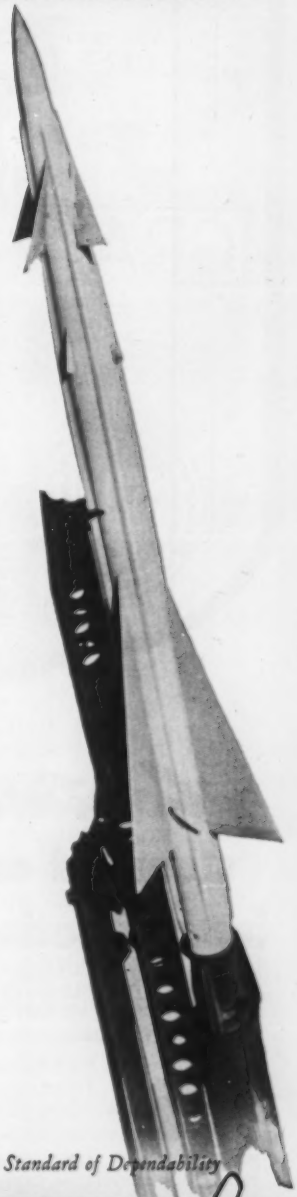
SPECIAL BLOWER

Whether your needs are for military or civilian specifications, Redmond has the development, testing, inspection, and packaging facilities to meet them.

Through the years Redmond has developed many mechanisms in the fractional horsepower field. Some of the products that either are being or have been produced in volume by Redmond are illustrated at the left. In the alterdyn, Redmond combined the dynamotor and inverter in one package. In dynamotor development, Redmond has reduced weight and frame size to a minimum. Other products are 400 cycle motors and actuator motors.

As the leading manufacturer of fractional horsepower electric motors, the Redmond Company is in a position to design, develop, and produce rotating electrical equipment. At the same time, the standard line of Redmond products can frequently be modified to meet performance and specification requirements.

Telephone, write, or wire Redmond Co., Inc., Special Products Division, Owosso, Michigan, and your problems will be given our immediate attention.



ADVERTISED IN The Saturday Evening POST

The Standard of Dependability

Redmond

COMPANY, INC.

OWOSSO, MICHIGAN

REDMOND

THE **BIG** NAME IN SMALL MOTORS

Circle 495 on page 19

Continental produces standard and special machines for our nation's largest industries

Shown here are a few of the trademarks of nationally known companies for which we have produced, in recent years, standard or special machinery of widely varied types.

Our 10-acre Birmingham plant contains the finest production facilities in the South. These include the area's largest machine shop, a complete fabricating and assembly plant and large Meehanite® foundry. Our engineers and craftsmen are skilled in working to exacting specifications and minute tolerances. Our standards of quality in workmanship and performance reflect our cumulative experience of 125 years.

We are equipped and ready to start on your job *now*. A call or a letter to any of our offices will bring a representative to discuss your requirements. Or further details without a personal call, if you prefer.

CG-5707

INDUSTRIAL DIVISION
CONTINENTAL GIN COMPANY
BIRMINGHAM, ALABAMA

CGC ATLANTA CLEVELAND DALLAS KNOXVILLE
MEMPHIS MOBILE NEW YORK 17

New Parts

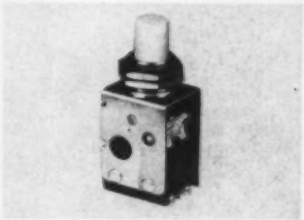
clear, blue-bright finish on zinc-plated parts. Iridite 14-9, a powdered concentrate designed to provide a one-dip, clear protective treatment for aluminum surfaces, operates at extremely low concentrations. It provides a high degree of corrosion resistance and meets requirements of MIL-C-5541. **Allied Research Products Inc.**, 4004 E. Monument St., Baltimore, Md.

Circle 733 on page 19

Pushbutton Switches

provide alternate action

Two alternate-action, maintained-contact pushbutton switches afford one-button control of two single-pole, double-throw circuits. Alternating action is provided by a beryllium-copper spring and nylon in-



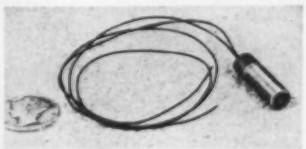
dex cam. Lighted model incorporates a subminiature incandescent lamp available for 6, 12 or 28 v. Unlighted model has the same switch circuitry, but requires only 1⅜ in. below mounting panel. Both switches employ precision subminiature basic switches rated at 5 amp, 125 or 250 v ac. **Minneapolis-Honeywell Regulator Co.**, Micro Switch Div., Freeport, Ill.

Circle 734 on page 19

Magnetic Pickup

is operable in temperatures to 250 F

Model 3055 subminiature pickup for use in aircraft and missiles generates electrical energy from me-

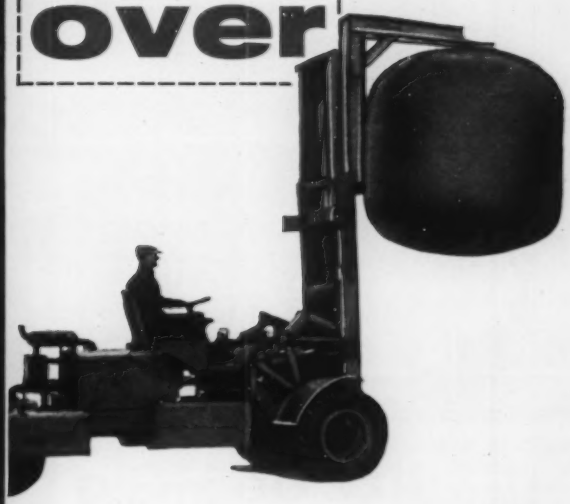


chanical motion without physical contact. Weighing about 4 grams, it translates movement of ferrous

Circle 496 on page 19

up and

over



The Payoff Power *is Chrysler*

Huge, collapsible rubber containers for economically storing and shipping flowable bulk are *filled, transported, loaded* with speed and ease by one man and a 12-ton Silent Hoist *Lift-O-Krane.* This unique fork truck-crane combination is powered by Chrysler for maximum-load performance with minimum maintenance . . . equipped with Chrysler gyrol Fluid coupling for smoother starting and acceleration, longer engine life.

CHRYSLER INDUSTRIAL 33, in-line 6 Engine (265 cu. in. displacement) powers the Silent Hoist Lift-O-Krane—and many other makes of equipment in the construction and materials handling fields. There are five Chrysler in-line 6s, two V-8s—ranging from 230 to 354 cu. inch displacement. For detailed information about Chrysler Industrial Power, write: Dept. C6, Industrial Engine Division, Chrysler Corporation, Detroit 31, Michigan.

Chrysler

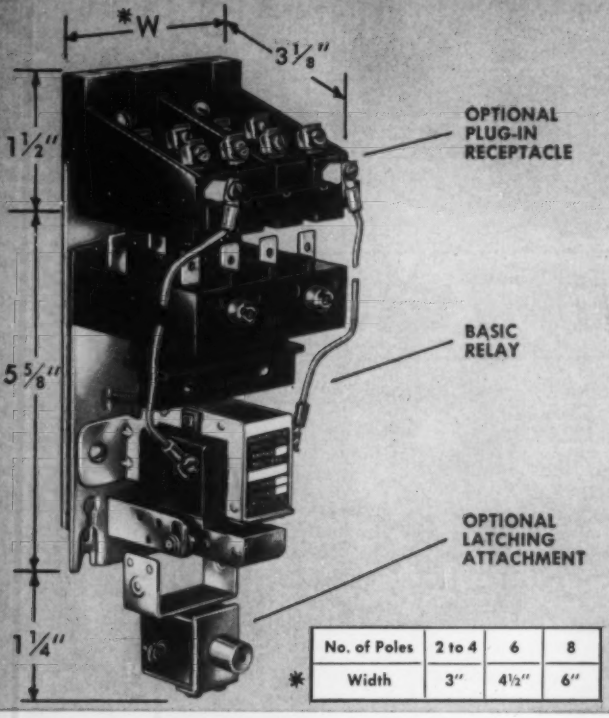
INDUSTRIAL ENGINES

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

Circle 497 on page 19

GREATEST VERSATILITY EVER OFFERED

in a Single Motor Control Design



No. of Poles	2 to 4	6	8
* Width	3"	4½"	6"

ARROW AH HART

New SIZE 00 and 0 RELAYS

600 VOLTS AC 10 and 15 AMPS
2 • 3 • 4 • 6 • 8 POLES

OPTIONAL PLUG-IN RECEPTACLE . . . minimizes down-time on high output machines; relay speedily replaced *without* disturbing wiring.

EASIEST CONTACT CONVERTIBILITY . . . from normally-open to normally-closed. No tools needed.

SIMPLIFIED FRONT REMOVAL OF COIL . . . fastest, easiest method of removing coil ever devised. Just remove 2 screws, swing to front, and lift out entire assembly.

HANDIEST LATCHING ATTACHMENT . . . another A-H exclusive, allows quick conversion to latching type relay . . . the *only* such single attachment quickly convertible in the field from "latch-in" to "latch-out" or "latch-in-and-out."

Available with AC and DC holding coils.

For complete information, write to The Arrow-Hart & Hegeman Electric Company, 103 Hawthorn St., Hartford 6, Connecticut.

ARROW AH HART

Quality since 1890

MOTOR CONTROLS • ENCLOSED SWITCHES
APPLIANCE SWITCHES • WIRING DEVICES

Circle 498 on page 19

New Parts

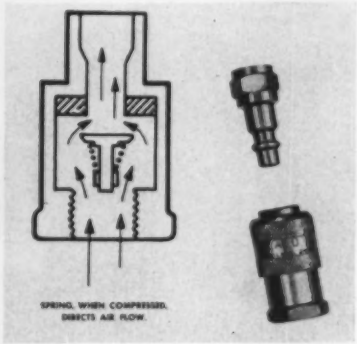
objects into a variable and measurable ac voltage. Output can indicate motion, torque, rpm or vibration. It actuates electronic counters, synchronizes machinery, controls circuits, and provides data for telemetering missiles and aircraft. Pickup, operable in temperatures to 250 F, has a ⅞-in. overall length and ¼-in. diam. **Electro Products Laboratories Inc.**, 4501 N. Ravenswood Ave., Chicago 40, Ill.

Circle 735 on page 19

Pneumatic Couplings

direct air flow
around compressed spring

Pt Series pneumatic couplings direct the air flow around the spring when it is compressed, instead of through it. This permits an air flow of better than 60 cfm at 100

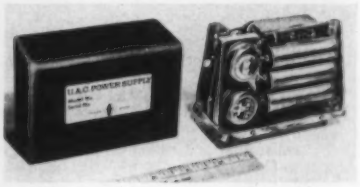


psi in ¼-in. size. A ⅜-in. size permits a flow of over 100 cfm at 100 psi. Sleeve of the coupling does not have to be retracted to insert connector. Unit has stainless steel shut-off valve, and is fully piloted to prevent cocking. **Zalo Mfg. Co.**, 4893 Van Epps Rd., Cleveland 9, O.

Circle 736 on page 19

Power Converters

change dc to ac



Lightweight, transistorized dc to ac power converters enable port-

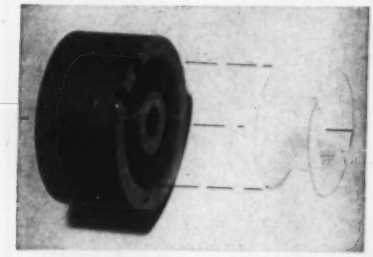
able, aircraft and vehicular electronic equipment to be battery-powered. Standard units produce up to 250 va from 28 v dc input; custom units are available to 2 kva. Converters can be made to meet military specifications. Also available for special applications are dc to 3-phase ac units. **Universal Transistor Products Corp.**, UAC Electronics Div., 143 E. 49th St., New York 17, N.Y.

Circle 737 on page 19

Nylon Bobbins

for ferrite-pot and cup-core applications

Nylon bobbins are of thin-wall construction and are held to close tolerances. Used for ferrite-pot



and cup-core applications, they fit most popular cores. **American Molded Products Co.**, 2727 W. Chicago Ave., Chicago 22, Ill.

Circle 738 on page 19

Pressure Control

for limited space and weight applications

J51 pressure-vacuum control, for applications where space and weight are limited, is available in

four models with adjustable ranges of 50, 75 and 250 psi between zero and 350-psi limits. Pressure settings are uncalibrated, are made by a knurled adjustment wheel located inside switch bracket. Three standard switch types are available:

(*Continued on Page* 192)

Film strip taken at high speed shows complex movement of thread in outsole stitching machine.

When 1/10 sec. "slowed" to 20 sec. the secret of the broken thread unfolded

Suppose you designed a machine that operated at 600-800 cycles per minute—and found that something was wrong.

In developing an outsole stitching machine, the Research Division of United Shoe Machinery Corp. of Beverly, Mass., faced the problem of occasional thread breakage from unknown causes. Since the mechanism operated at 600-800 stitches per minute, the problem couldn't possibly be traced by visual inspection.

Engineers found the answer with high speed movies. Using a Kodak High Speed Camera, they were able to film the operation of the stitching machine at 3200 frames per second. When they projected the film at a normal 16 frames per second, the duration of a single stitch, actually 1/10 of a second, was slowed to *20 seconds* on the screen.

The movies clearly showed that thread breakage resulted from dynamic conditions which upset the timing of the cam shaft and associated linkage, and from unsuspected paths of thread motion caused by the operating speed of the machine.

Perhaps you, too, face machine design problems which conventional methods cannot solve. You'll find the answers quickly and at a minimum cost of time, money, and manpower—with high speed movies.

For complete details send for the free booklet, "High Speed Motion Pictures at the Service of the Engineer."

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

the Kodak *HIGH SPEED* Camera

Kodak

Circle 499 on page 19

Circle 498 on page 19

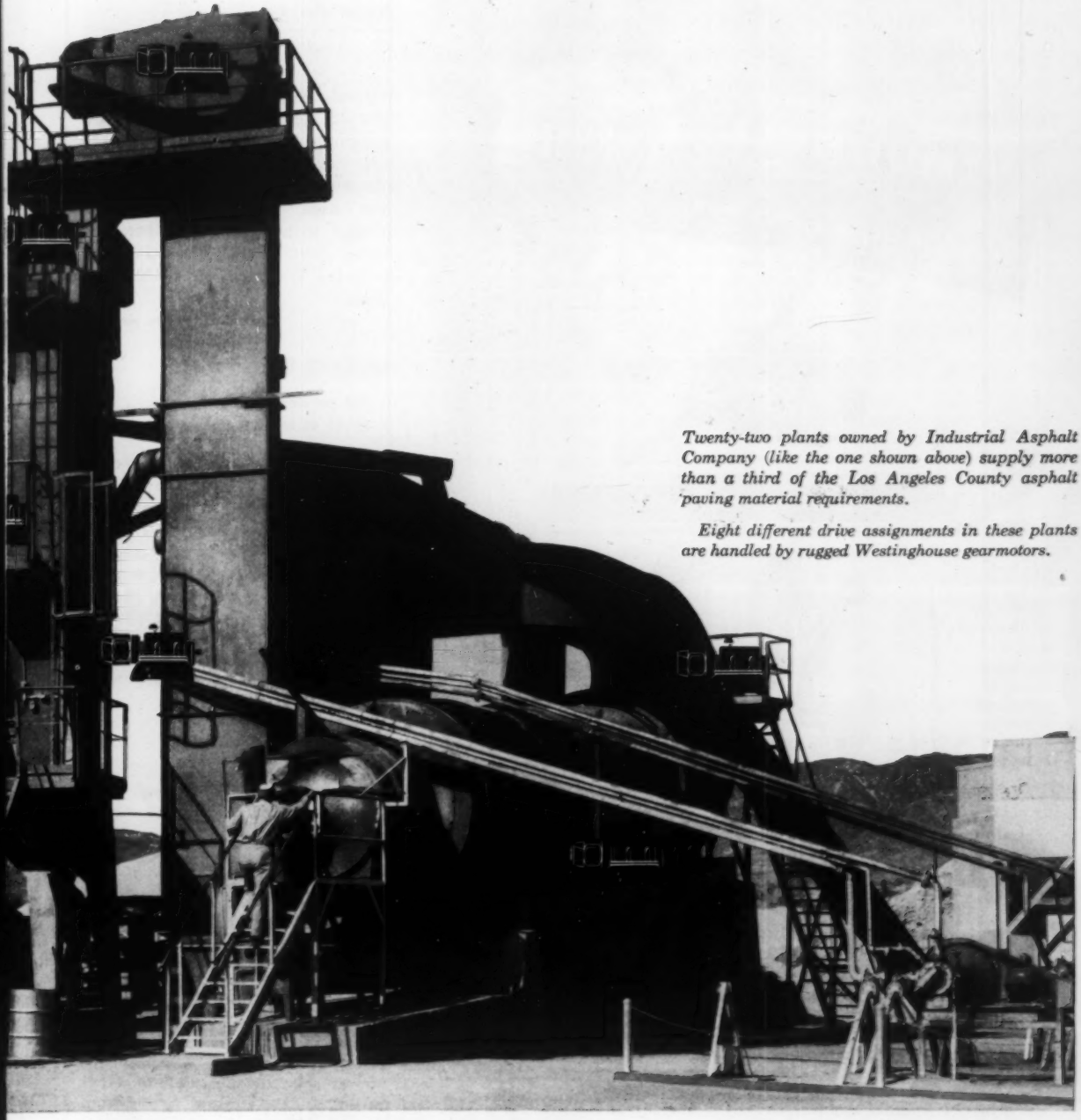
MIXING NEARLY 2 MILLION TONS OF ASPHALT YEARLY . . .

WESTINGHOUSE GEARMOTORS SET 15-YEAR DEPENDABILITY RECORD

Mounted on top of a 36-foot high aggregate elevator, this Westinghouse gearmotor moves 6600 lbs. of rock a minute from the ground to the vibrating screen. There has not been one failure in 15 years in either motor or gearing despite repeated high torque requirements and adverse weather conditions.

"We have used Westinghouse gearmotors in our plants for more than 15 years," reports E. J. Woodward, Chief Engineer of Industrial Asphalt, Los Angeles. "Gearmotors driving the hot elevators take the toughest strain. Most of these units have been operating 15 years without replacement or addition of new bearings or motor armature. These drives take occasional overloads safely, too. For example, we've increased output from 230 to 283 tons per hour without a failure."

"As a manufacturer of these asphalt plants, we demand absolute dependability in all components,"



Twenty-two plants owned by Industrial Asphalt Company (like the one shown above) supply more than a third of the Los Angeles County asphalt paving material requirements.

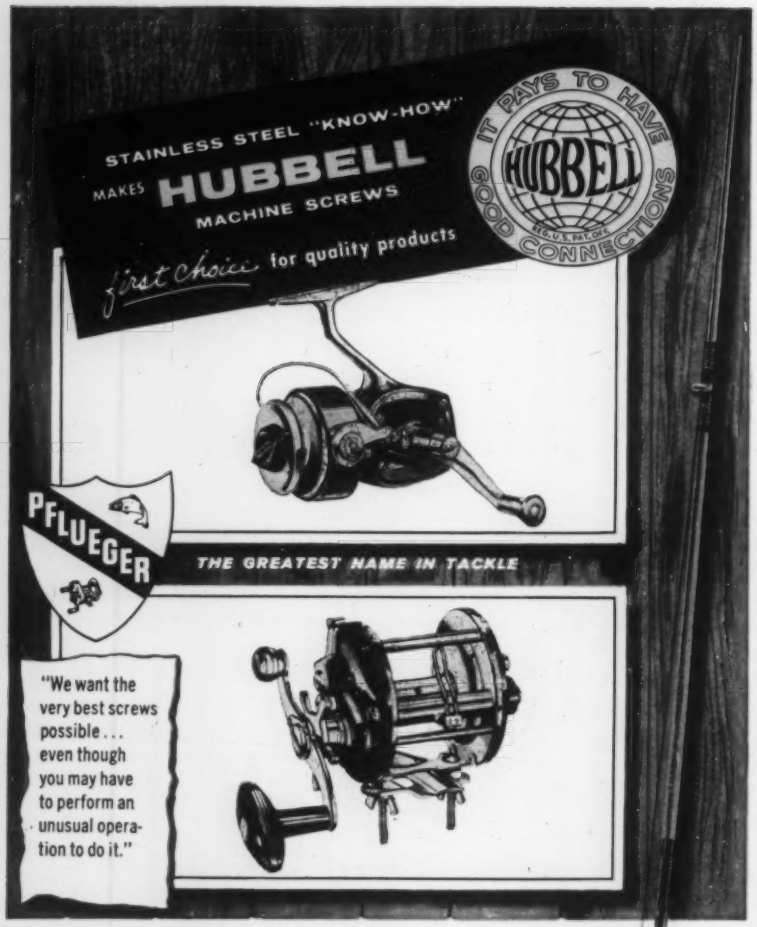
Eight different drive assignments in these plants are handled by rugged Westinghouse gearmotors.

remarked M. B. Preeman, of Standard Steel Corporation. "Dependable service is the primary reason for using Westinghouse gearmotors in Standard Steel asphalt plants."

Here's another example of the type of service you can expect from Westinghouse gearmotors and speed reducers. You can get immediate delivery in horsepower ratings from 1 to 100; reduction ratios to 58.3:1. Call your local Westinghouse sales engineer, or write, Westinghouse Electric Corporation, Gearing Division, 200 McCandless Avenue, Pittsburgh, Pennsylvania. J-07355

YOU CAN BE SURE...IF IT'S

Westinghouse


STAINLESS STEEL "KNOW-HOW"
MAKES HUBBELL
MACHINE SCREWS
first choice for quality products
IT PAYS TO HAVE GOOD CONNECTIONS
HUBBELL
REG. U.S. PAT. OFF.
PFLUEGER
THE GREATEST NAME IN TACKLE
"We want the very best screws possible... even though you may have to perform an unusual operation to do it."

The above statement is taken from the machine screw specifications of the Enterprise Mfg. Co., Akron, Ohio. It expresses their dedication to top quality, and it shows why so many other quality manufacturers, like Pflueger, are turning to Hubbell for their screw requirements.

This is particularly true in regard to austenitic chromium-nickel stainless steel machine screws, which require unusual manufacturing know-how. The ability, for example, to eliminate cracking which sometimes results from fabricating stresses; the ability to insure high tensile strength with maximum corrosion resistance; the ability to maintain pleasing appearance: all of these things are the result of long experience with stainless steel. In fact, Hubbell is the oldest company in the country making stainless steel machine screws.

This specialized knowledge is yours for the asking. For price and delivery information send blueprint or sample of the item.

HARVEY HUBBELL, INC.

HIGHEST QUALITY
WIRING DEVICES • MACHINE SCREWS

OVER 60 YEARS' EXPERIENCE in the manufacture of highest quality, rolled thread machine screws and special cold headed parts.

MACHINE SCREW DEPARTMENT BRIDGEPORT 2, CONNECTICUT

New Parts

(*Continued from Page* 189)

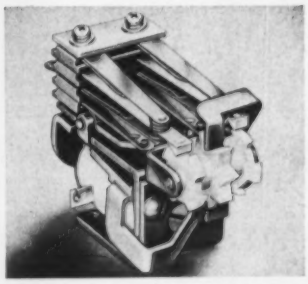
normally open, normally closed, and double throw with no neutral position. Switches are rated to 15 amp at 115 or 230 v ac. Bellows material is type 321 or 347 stainless steel. Mounting is accomplished with ⅛-in. NPT pressure connection. **United Electric Controls Co.**, 79 School St., Watertown, Mass.

Circle 739 on page 19

Sequence Relays

for predetermined cycle of operation

Frame 211 miniature sequence relays are for use wherever a predetermined cycle of operation is needed. Double-cam movement permits contacts to be adjusted to operate when coil is de-energized. Relays have double-pole, single-throw or double-pole, double-throw contacts which can be set to open, close, or transfer in any desired sequence. Continuous-duty coils



in ratings to 115 v dc or 230 v ac are available. Power consumption is 5 to 6 w dc or 10 to 12 va ac. Heavy flexing contacts carry 150 per cent of rated load. Contacts are fine silver convex buttons, mounted on phosphor-bronze flexing arms. Ratchets and cams are Nylon. **Struthers-Dunn Inc.**, Lambs Rd., Pitman, N. J.

Circle 740 on page 19

Clutches and Brakes

have new poleshoe and hub assembly

Miniature electromagnetic clutches and brakes are for applications requiring zero-drag release with poleshoe and hub assembly. Unit provides complete release when clutch or brake is de-energized and zero

COMPACT . . . POWER-PACKED TRI 55 CLAD MOTORS

Plan now to use G-E TRI 55 CLAD motors in ratings to 125-hp

REG. U.S. PAT. OFF.

Increased production throughout U.S. industry has created a demand for more powerful machines with greater speeds and increased capacity. To meet this demand, General Electric will soon announce a wider range of Tri-Clad '55' motors in compact . . . power-packed dimensions.

ADVANCE INFORMATION—Experienced engineers and skilled craftsmen have utilized revolutionary new materials and the most modern production techniques to pack more power into these larger G-E motors built to new NEMA standards. The more rugged, higher horsepower motors will feature easy installation, reduced maintenance, and long-life performance.

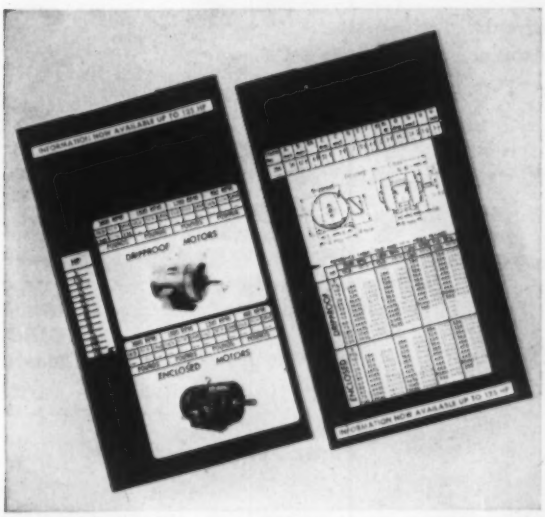
PLAN AHEAD—New Tri-Clad '55' motors can mean real savings in your plant modernization project and in new product design. For complete details on the wider range of motors, contact your nearest General Electric Apparatus Sales Office. For advance size information, send in the attached coupon for free slide rule. General Electric Company, Schenectady 5, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC

FREE SLIDE RULE

ADVANCE INFORMATION TO HELP YOU PLAN AHEAD



FREE SLIDE RULE—Write for free slide rule which lets you determine at a glance the weight and space-saving benefits of new Tri-Clad '55' motors up to 125-hp. This handy slide rule provides advance information to solve your design problems . . . to benefit your over-all operation.

SECTION C891-2

GENERAL ELECTRIC COMPANY

SCHENECTADY 5, NEW YORK

I would like advance information on new dimensions of Tri-Clad '55' motors up to 125-hp. Please send me free slide rule.

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CITY & STATE_____

help clean dirty streets

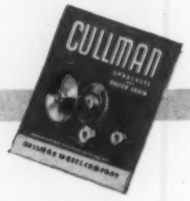
Around sharp corners on highways, parks, streets, alleys, Mobil-Sweepers cut street-sanitation costs 45%. And, do it with low maintenance expense. These efficient vehicles, built by the Conveyor Company in Los Angeles, eliminate extra pick-up and hauling equipment. They sweep from 1½ to 10 m.p.h. . . . carry away full loads at truck speeds. And, reduce street-sanitation to a simple, safe, one man operation.

To insure such performance Cullman chains and sprockets are used throughout. They rotate the sweeping brooms and drive the conveyor that feeds dirt into the hopper. Operating under wet or dry abrasive conditions they overcome shock loads, extend equipment service life, lower upkeep costs.

here's how chain drives can work for you . . .

On your products too, Cullman chains and sprockets can achieve similar advantages, help deliver top performance. Next time you're faced with a power transmission problem write direct or call in a Cullman man. He'll be glad to assist you . . . and recommend the right chain drive for your job.

For the full story on the Cullman power transmission line — roller chains, sprockets and flexible couplings, write today for catalog No. 51, or see your local Cullman Distributor.



cullman
POWER TRANSMISSION
ROLLER CHAINS AND SPROCKETS

REPRESENTATIVES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES
CULLMAN WHEEL COMPANY, 1336 ALTGELD STREET, CHICAGO 14, ILLINOIS

Circle 503 on page 19

New Parts

backlash when it is energized. Units handle up to 3 deg angular misalignment without binding or loss of power. Clutches or brakes in either 100 or 130 series are available with the assembly. Series 100 units measure 15/16-in. diam

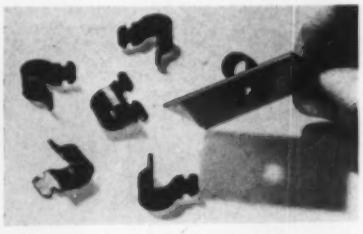
by 2 in. long and deliver torque in excess of 3 lb-in. Series 130 units measure 1 5/6 in. diam by 2¾ in. long and deliver 7 lb-in. torque. Maximum power consumption is 3 w. **Dial Products Co.,** 9 Avenue E, Bayonne, N.J.

Circle 741 on page 19

Cable Clips

are of one-piece construction

Black Nylon cable clips have excellent insulating properties, toughness over a wide range of temperatures, resistance to corrosion, and



are nonmagnetic. Of one-piece construction, they eliminate the need for screws, fasteners and other small parts in anchoring cable and tube. **Weckesser Co.,** Dept. MDC, 5701 Northwest Highway, Chicago 30, Ill.

Circle 742 on page 19

Phase Voltage Converter

changes single to three phase current

Compact, lightweight, drip-proof unit converts single-phase, 115-v, 60-cycle ac to three-phase, 230-v, 60-cycle current. Frequency is held

write today for this **FREE** *24 page catalog*

Newly e-x-p-a-n-d-e-d line of

ELECTRA MOTORS, INC.
1110 No. Lemon St., Anaheim, California

Please send me catalog 60-2 describing your line of Electra-Gearmotors & Electra-MC-Gearmotors.

Name _____

Firm _____

Address _____ *Zone* _____

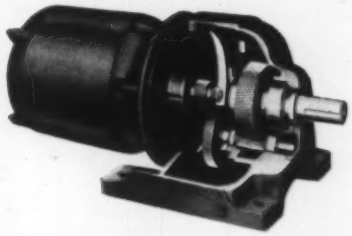
City _____

State _____

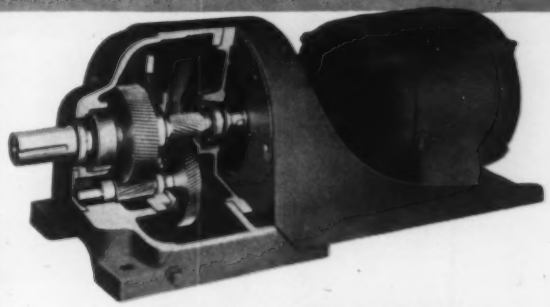
ELECTRA-GEARMOTORS
ELECTRA M-C GEARMOTORS

PARALLEL SHAFT • ½ HP through 60 HP

Electra-Gearmotors feature *permanent alignment* for maximum gear life . . . *greatest protection* against oil leakage . . . *precision hardened helical gears* . . . *splash lubrication* on all moving gear head parts . . . and, extended motor life is assured with ELECTRA *Glamicone Insulation* for added protection to every Electra Motor. It will pay you to investigate. Send for complete catalog today.

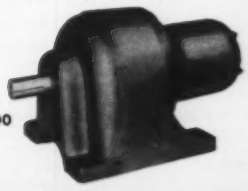


Parallel Shaft, Series 6000 — Foot Mounted
Gear case and motor integrally mounted
½ through 30 horsepower



Parallel Shaft, Series 6000 — Motor Coupled
Gear case with mounting bracket and foot mounted motor
1 through 60 horsepower

Single Reduction, Series 6100
Foot Mounted



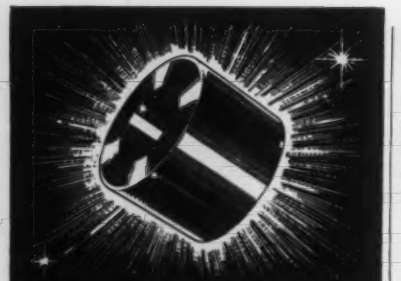
Triple Reduction, Series 6300
Foot Mounted

Double Reduction, Series 6200
Motor Coupled

Triple Reduction, Series 6300
Motor Coupled

ELECTRA MOTORS, INC.
1110 No. Lemon St., Anaheim, Calif.
Phone KEystone 5-6061

First in Aluminum . . . Foremost in Quality



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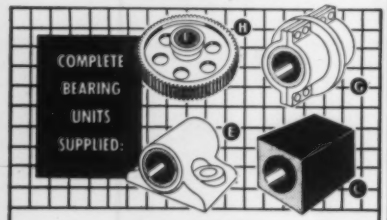
GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



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☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE

COMPANY

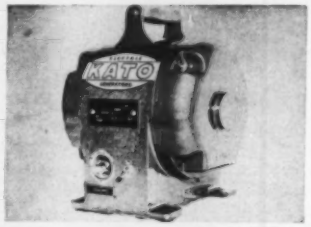
STREET

CITY ZONE STATE

Circle 505 on page 19

New Parts

constant within a fraction of a cycle. Aluminum alloy frame houses capacitor starter and both output and input receptacles. Equipped with vibration dampeners, unit



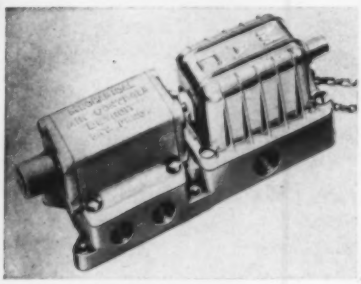
changes phase and voltage for sound track equipment when placed a few feet from recording equipment. Converter shown is rated at 500 w. **Kato Engineering Co.**, Mankato, Minn.

Circle 743 on page 19

Air Valve

has independent body and solenoid

Air valve meets all JIC requirements. Completely independent body and solenoid permit separate removal of either from base without disturbing the other. Improved solenoid has shock - resistant mountings. Integral conduit box



makes valve more compact. Unit is available in ⅜-in. single-solenoid, double-solenoid and three-way models. **Mechanical Air Controls**, 10030 Capital, Oak Park, Detroit 37, Mich.

Circle 744 on page 19

Heavy-Duty Mounting

has excellent vibration isolation performance

Heavy-duty Temproof mounting is for use on heavy electronic equipment. It features load capacities above 60 lb, temperature resist-

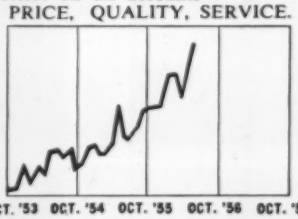
Does VOLKSWAGEN bother Cadillac?

We don't make CADILLAC air cylinders and we don't pretend that we do . . .

We do claim that we make very good cylinders at very good prices:

BORE	BASIC PRICE	ADD PER " OF STROKE
1⅛"	$15.50	$.35
1½"	$20.50	$.50
2"	$25.50	$.55
2½"	$29.50	$.65
3"	$32.50	$.95
4"	$47.50	$1.20

We furthermore claim that we work hard to ship from stock and our sales chart tells us that we are being successful on all accounts — PRICE, QUALITY, SERVICE.



Besides cylinders, we also make the ALLENAIR line of AIR VALVES, AIR CLAMPS and DIAL FEED TABLES and if we could tell you right here all there is to tell you about what we offer and how those products can increase your PRODUCTION at MINIMUM COST we wouldn't need the $1.25 24-page catalogue that is available for free this month to anyone seriously interested.

THE A. K. ALLEN CO. MD-67
57 Meserole Ave., Brooklyn 22, N. Y.

Name.....

Company.....

Address.....

City.....Zone.....State.....

P.S.—*The cylinder pictured is a Factory Reject. The only rods available are straight ones and made out of #416 Stainless Steel ground and polished stock and repolished after machining. The bearing is nylon.*

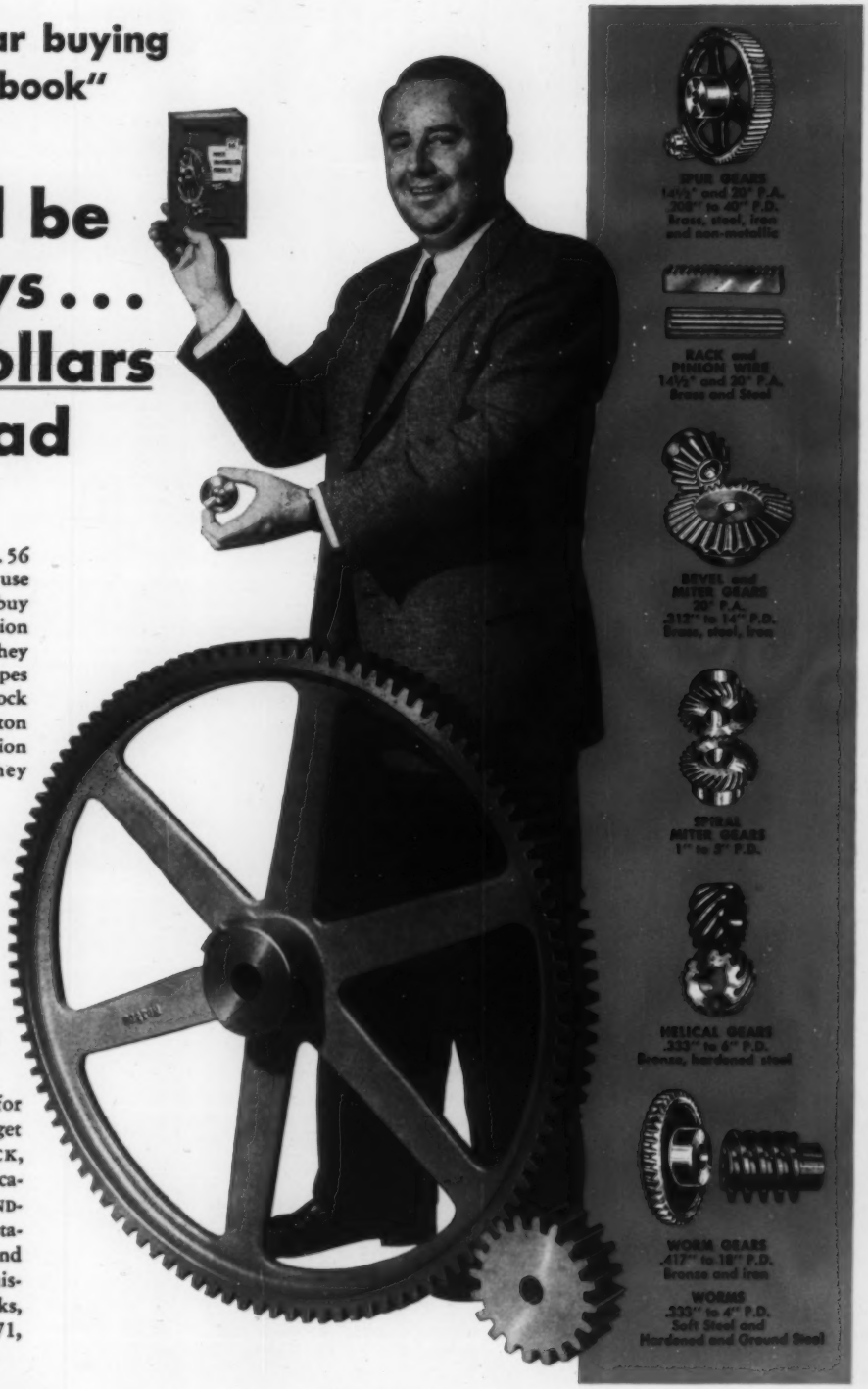
The answer to the question on top of this page is: *Not one bit. There is a market for both!*

ALLENAIR THE A. K. ALLEN CO.
57 Meserole Ave., B'klyn 22, N. Y.

Circle 506 on page 19

Plan your gear buying with "the book"

You'll be days... and dollars ahead



The Boston Gear Catalog No. 56 is "the book" in constant use by men who specify and buy gears and other transmission parts, — for good reasons. They know it lists over 2000 types and sizes of standardized stock gears. They know that Boston Gears are top-rated for precision and performance. And they know, also, they can get

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Why pay more (and wait) for "specials" when you can get Boston Gears FROM STOCK, nearby, to meet any specification? Be cost-wise . . . STANDARDIZE. Get your copy of Catalog No. 56. You'll be days and *dollars* ahead on any transmission job. Boston Gear Works, 64 Hayward Street, Quincy 71, Massachusetts.

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the new DINGS *hazardous-location* MAGNETIC DISC BRAKE

Approved by UNDERWRITERS LABORATORIES

for:

Class I, Group C	Class I, Group D	Class II, Groups E, F, G
Explosive atmospheres containing ethyl ether vapors, ethylene, or cyclopropane.	Atmospheres containing gasoline, benzine, propane, alcohol, lacquer solvent vapors, etc.	Atmospheres containing metal dusts; coal or coke dust; flour, starch or grain dust, etc.

Now you can get the best brake on the market to protect men and machinery in three classes of hazardous locations. Dings "707" Series Hazardous-Location Magnetic Disc Brakes are built to withstand an internal explosion within Underwriters Laboratories limiting requirements for Class I, Group D hazardous locations. Dings "709" Series also meets hazardous location requirements and, in addition, contains a thermal release which automatically releases the brake if the housing temperature approaches the limit set by U. L. for possible ignition of gases, vapors or various dusts included in Class I, Group C or Class II, Groups E, F and G.

Dings new Hazardous-Location Brakes are designed with all the outstanding advantages that make Dings Magnetic Disc Brakes first choice of Motor Manufacturers for either motor mounting or foot mounting.

check the complete line of DINGS *direct-acting* MAGNETIC DISC BRAKES

Eighteen models, with a torque range of 1½ to 175 lbs. ft., meet every requirement, are designed for mounting on all old and new re-rated NEMA type "C" motor flanges and to accommodate standard NEMA shaft extensions.

"THRU-SHAFT" applications for facilitating direct coupling, use of hand cranks, tachometer, plugging switch, pulleys, etc., are easily accomplished by a simple modification of the cover.

Always specify Dings Brakes from your regular motor supplier . . . or take advantage of Dings complete engineering service for your brake problems. Write for details today.

DINGS BRAKES, Inc.
A Subsidiary of Dings Magnetic Separator Co.
4714 West Electric Ave.
Milwaukee 46, Wis.

DB-257-1/3

New Parts

ance from −80 to 250 F, and excellent vibration isolation performance in severe operating conditons. Unit meets requirements of MIL-C-172B, and is self-damping in its resonant range. Mounting supports loads in either upward or downward direction. **Lord Mfg. Co.**, 1635 W. 12th St., Erie, Pa.

Circle 745 on page 19

Stainless-Steel Strip

in extremely close tolerances

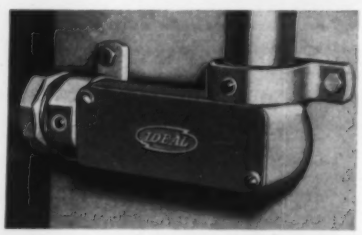
Stainless-steel strip rolled to thicknesses as low as 0.0005-in. with thickness tolerances of ±0.0001-in. is available for use on dials, nameplates and related items. Available in 300 stainless steel, strip has high strength and excellent resistance to heat and corrosion. **American Silver Co.**, 36-07 Prince St., Flushing 54, N. Y.

Circle 746 on page 19

Fittings Bracket

for rectangular conduit fittings

Hub-Lug bracket provides a simple, quick fastening method for mounting of rectangular fittings in



electric control and operating systems. Use of the bracket eliminates drilling and tapping holes in fittings for fastening, eliminates leakage, and provides greater flexi-

Circle 508 on page 19

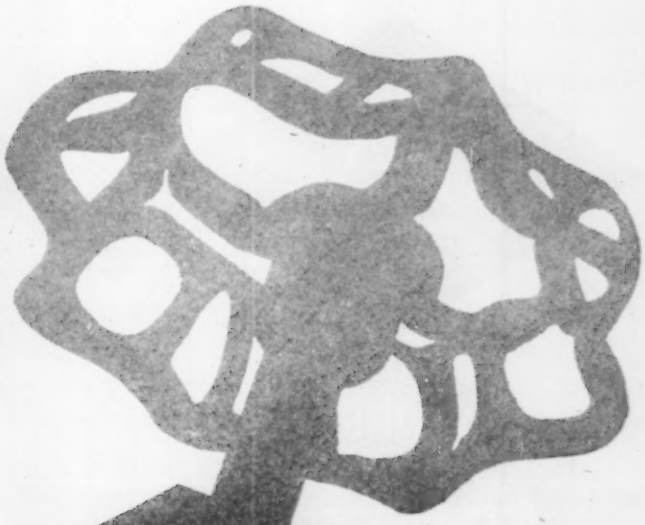
JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

SINCE 1864 TRADE JENKINS MARK

Jenkins Bros

Sold Through Plumbing, Heating and Industrial Distributors



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If you will put
a Jenkins Valve,
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where you cannot keep
other valves tight —
and if it is not perfectly tight
or it does not hold steam, oil, acids,
water or other fluids longer
than any other valve,
you may return it and your money
will be refunded.

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This famous Fair Offer,
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gives the buyer of Jenkins Bronze, Iron and Steel Valves
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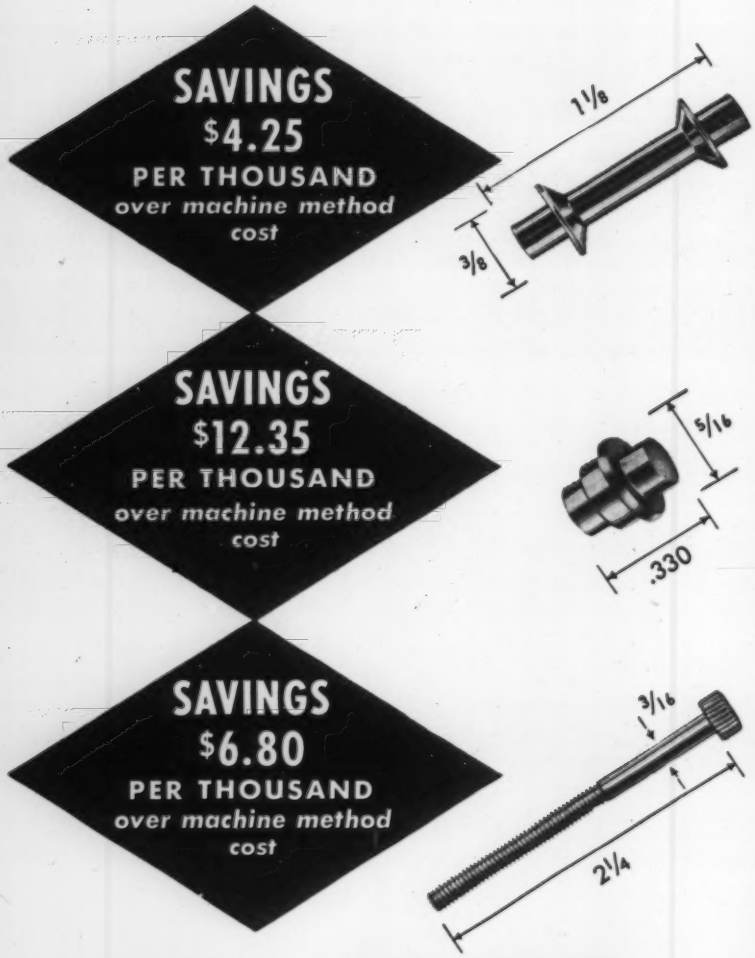

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Cold-Heading is the most versatile, most economical method for producing your fasteners and small parts. These case histories are typical of thousands of money saving jobs we've done for our customers. May we quote on your requirements? Write today for the Hassall Catalog.

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SINCE 1850

NAILS, RIVETS, SCREWS
AND OTHER COLD-HEADED
FASTENERS AND SPECIALTIES

Hassall

Circle 510 on page 19

New Parts

bility in the design of electrical systems. Bracket is placed over conduit, required fittings are attached to conduit, bracket is slipped back down over hubs on fittings, tightened with wrench, and fittings are secured to surface through holes in wings of bracket. **Ideal-Simplet Fittings Inc.**, 1059 Park Ave., Sycamore, Ill.

Circle 747 on page 19

Dc-Ac Choppers

generate 120-cps square wave

Frequency-doubler dc-ac choppers multiply the 60-cps excitation frequency, generating a 120-cps square wave. They are available in 23 models, single and double-pole, for use on commercial 60-

cycle ac power. Units have a tolerance of $\pm \frac{1}{2}$ cps. They can be mounted vertically or horizontally. Temperature range is 0 to 43 C. **Stevens-Arnold Inc.**, 22 Elkins St., South Boston, Mass.

Circle 748 on page 19

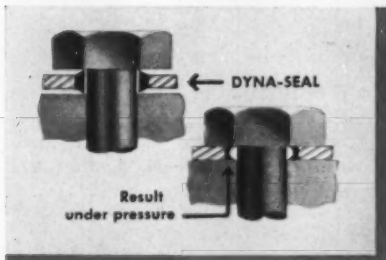
Gearmotors

parallel-shaft types in wide size range

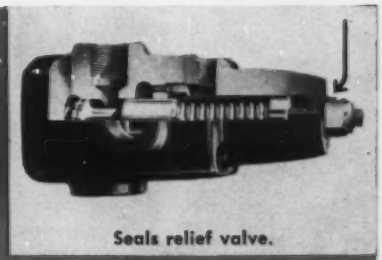
Parallel - shaft gearmotors are available in both integrally-mounted and motor-coupled types. Units with integrally-mounted gear heads and motors are space-saving and easily installed. Permanent alignment is built in to provide for extended gear life. Double seals on honed surfaces of high-speed shafts protect against oil leakage. Motor-coupled types permit changing motors on the job without draining oil. Splash lubrication of all moving gear-head parts minimizes wear and aids in transfer of heat. Motors have glass-mica and

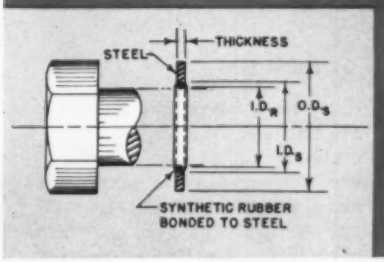
Problem A simple, low cost solution to a face-to-face sealing problem

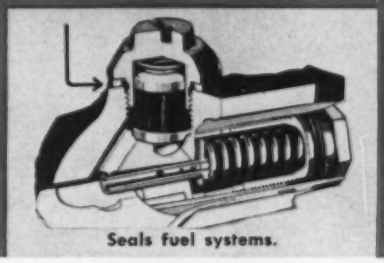
Solution **Precision Dyna-seal®**



Seals hydraulic control manifold.


Seals relief valve.




Seals fuel systems.

Seals aircraft fittings.

Easy-to-handle one piece seal of rubber bonded to a steel washer.

- No special machining required.
- Reduces assembly costs.
- Positive sealing up to 10,000 P.S.I.
- Vibration proof, lock washer action.
- Reduces bolting torque.
- Reusable—cuts maintenance.

Available in-stock sizes for No. 5 screw to 1¼" bolt or from ⅛" to 1¼".

Let a Precision engineer demonstrate the Dyna-seal cost and labor saving advantages to you. Write today!

PRECISION PART NO.	BOLT SIZE (MAX. O.D.)	I.D.S ±.003	O.D.S ±.003	I.D.R +.000, −.004	THICKNESS ±.0025
110-5	.125	.195	.315	.145	.041
110-6	.138	.208	.328	.158	.041
110-8	.164	.234	.364	.184	.041
110-3/16	.190	.281	.422	.220	.054
110-7/32	.216	.307	.453	.246	.054
110-1/4	.250	.341	.516	.280	.054
110-5/16	.312	.403	.594	.342	.054
110-3/8	.375	.466	.687	.405	.054
110-7/16	.437	.528	.766	.467	.075
110-1/2	.500	.601	.875	.540	.075
110-9/16	.562	.663	.969	.602	.075
110-5/8	.625	.726	1.062	.665	.075
110-11/16	.687	.788	1.156	.727	.090
110-3/4	.750	.865	1.266	.800	.090
110-13/16	.812	.927	1.359	.862	.090
110-7/8	.875	.990	1.453	.925	.090
110-15/16	.937	1.052	1.531	.987	.090
110-1	1.000	1.135	1.656	1.050	.090
110-1⅛	1.125	1.260	1.844	1.175	.090
110-1¼	1.250	1.385	2.016	1.300	.134

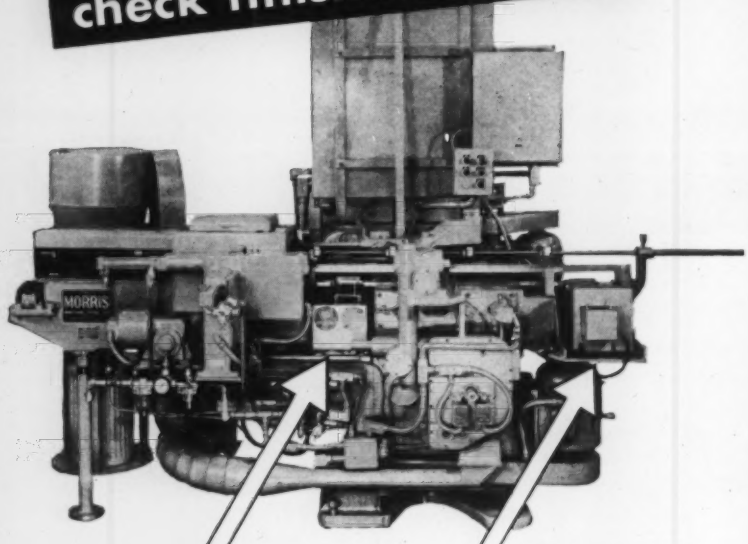
Write for your free copy of the Precision catalog on Dyna-seals.

Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio Canadian plant at: Ste. Thèrése de Blainville, Québec

Built-in SCALES pre-set machine and check finished product



PRE-SET BY EXACT WEIGHT

In MORRIS PISTON MILLING MACHINE, scale No. 1 determines amount of overweight that must be removed to balance pistons. Linkage transfers reading to depth of cut and sets machine for milling off the correct amount of excess pad.

INSPECTED BY EXACT WEIGHT

After milling, piston travels to the second scale where it is checked against predetermined weight. The SHADOGRAPH scale is adjusted to one gram, plus or minus. Should final check show over or under this amount, machine is automatically stopped.

The above application shows how EXACT WEIGHT precision designed scales can be fitted into modern machine tooling to bring your operations a step nearer automation.

If you are now designing machines or products that require accurately controlled weight as a part of their manufacture, investigate our SHADOGRAPH Scale application. These scales can be easily built into most modern production machines. Their absolute accuracy adapts itself to complete electronic application and control.

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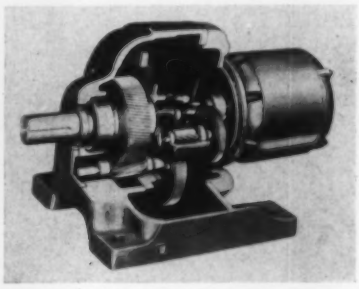
Exact Weight SCALES

BETTER QUALITY CONTROL . . . BETTER COST CONTROL

New Parts



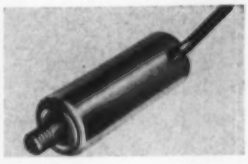
silicone insulation. Motor housings and smaller gear cases are heat-treated aluminum alloys. **Electra Motors Inc.**, 1110 N. Lemon St., Dept. P I, Anaheim, Calif.

Circle 749 on page 19

Miniature Solenoid

has low plunger friction loss

Pull-type solenoid for aircraft, missile and electronic applications operates with high efficiency and very low plunger friction loss. Operating temperature range is −65 to 100 F. Unit meets requirements of MIL-S-4040. Operating voltage is from 6 to 100 v dc with plunger



operating under side force of 8 to 10 *g*. **Carruthers & Fernandez Inc.**, 1501 Colorado Ave., Santa Monica, Calif.

Circle 750 on page 19

Pushbuttons and Switches

have molded, wrap-around cover

Standard-duty pushbuttons and selector switches have a molded, wrap-around cover which contains and protects contact mechanism. Molded Bakelite shield completely covers and protects mechanism when cover is removed. Matching ribs in molded cover of pushbutton assemblies and notches in terminal base make it impossible to mount cover incorrectly. Pushbutton stations are available in NEMA 1 enclosures with one, two and three buttons, or two buttons and pilot

BERNARD SIMONS, Senior Project Engineer on the Convair 880 Jetliner. A graduate of the University of Detroit, Mr. Simons joined Convair-San Diego nine years ago as an engineering designer. He is respected for his contributions to jet airliner advancement — as well as his ability to develop engineering talent.

"Engineers...here's how we combined aileron and spoiler functions in our new Convair 880 Jetliner."

"Consistent with our 34-year record of significant contribution to aircraft development, a selected group of engineers at CONVAIR-*SAN DIEGO* accepted the challenge to develop a *new* control surface concept for the Convair 880 – world's fastest jet airliner.

"Working as a team, we created a *mechanical* mixer, which combined, for the first time on any commercial aircraft, the control of ailerons and spoilers. These surfaces function as both speed brakes *and* lateral controls, and because the mixer affords direct connection to the surfaces, it gives pilots *positive* feel of the controls. Its mechanical design of bellcranks and levers permits fewer adjustments and easier, less costly maintenance to airlines operating the Convair 880.

"Important as this project is, it represents only *one* of the many creative assignments being solved at CONVAIR-*SAN DIEGO* – projects like our 880 Jetliner and F-102A Interceptor.

"You will enjoy this *diversity* of activity. You'll like the Convair atmosphere, where you see and feel accomplishment. And you will enjoy living in beautiful, smog-free San Diego.

"For greater career opportunity, for stimulating diversity – *for your future's sake* – send for more information about CONVAIR-*SAN DIEGO today!* Write Mr. H. T. Brooks, Engineering Personnel, Dept. 66-G."

CONVAIR

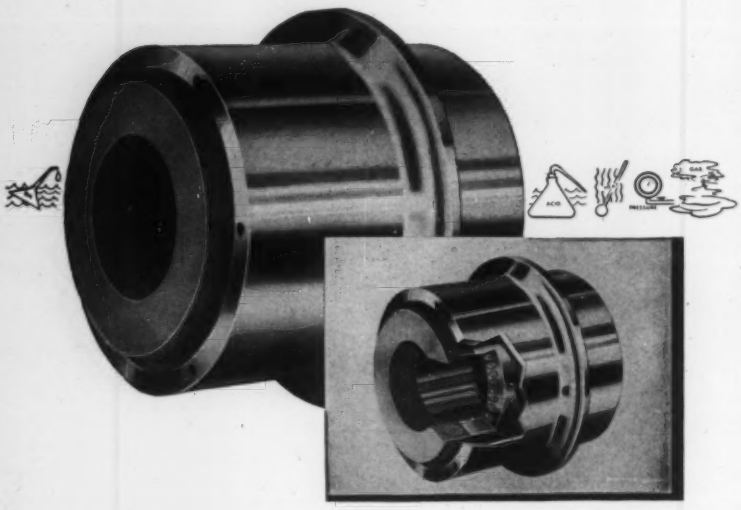
SAN DIEGO

3302 Pacific Highway, San Diego, California

CONVAIR IS A DIVISION OF GENERAL DYNAMICS CORPORATION

Circle 513 on page 19

SPECIAL



nothing can touch this winding

Oil, acid, vapor, heat and pressure don't affect this AC motor winding. It's completely encased in a special, high-temperature, chemical-resistant plastic. The windings are cast right in the plastic to make a single, solid, impervious piece.

Of course, this winding goes into a special motor — one that's designed to run in a pressurized atmosphere of inert gas, under constant exposure to a piping-hot oil splash and vapor at over 200°F. Temperature-stabilized bearings, oil lubricated under pressure, and drip-proof, corrosion-resistant construction are some other design necessities for this unique 115-volt, 1/3 hp AC motor.

Here is a typical example of ESCO's unusual ability to design and build rotary electrical equipment to meet special customer needs. Whether or not your particular motor problem is this special, remember that ESCO's twenty years of broad experience is always available to you. No motor or generator problem is too big or small, too routine or specialized for ESCO engineers and craftsmen to solve properly, the way you want it solved.

Refer to Esco Catalog in section 4a/El in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem . . . we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

New Parts

light. Selector switches also have wrap-around cover, and can be changed quickly from two to three-position switches. Pushbutton and selector switch contacts are of double-break, silver-alloy

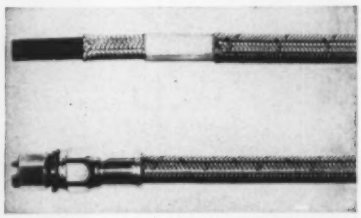
construction. Ac-contact ratings are 3 amp, 110 v; 2 amp, 220 v; and 1 amp, 440-550 v. Dc ratings are 1 amp, 115 v; 0.5 amp, 230 v; and 0.2 amp, 550 v. **Allen-Bradley Co.**, 136 W. Greenfield Ave., Milwaukee 4, Wis.

Circle 751 on page 19

Hose Assemblies

for 3000-psi hydraulic systems

Fluoroflex-T R700 hose and R25800 Teflon hose assemblies, available in -4 and -6 sizes, are for use in 3000-psi hydraulic systems. Hose assemblies are chemically inert to



natural and synthetic hydraulic fluids and completely unaffected by acids, alkalis and oxidizing agents. Temperature range is from −65 to 400 F. **Resistoflex Corp.**, Woodland Rd., Roseland, N.J.

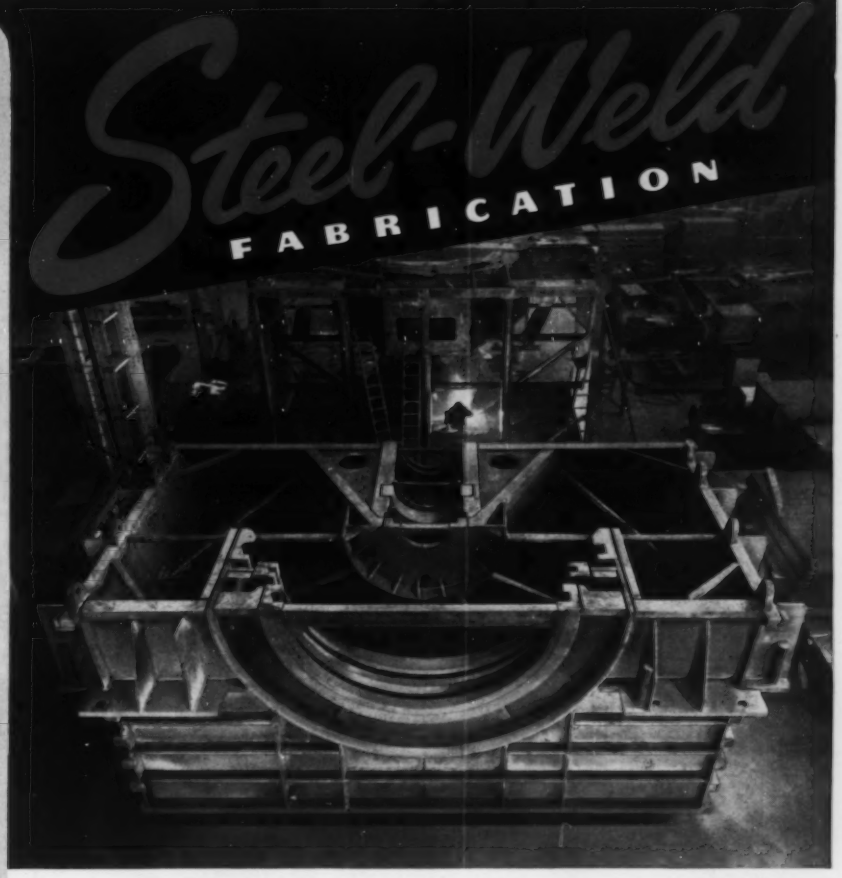
Circle 752 on page 19

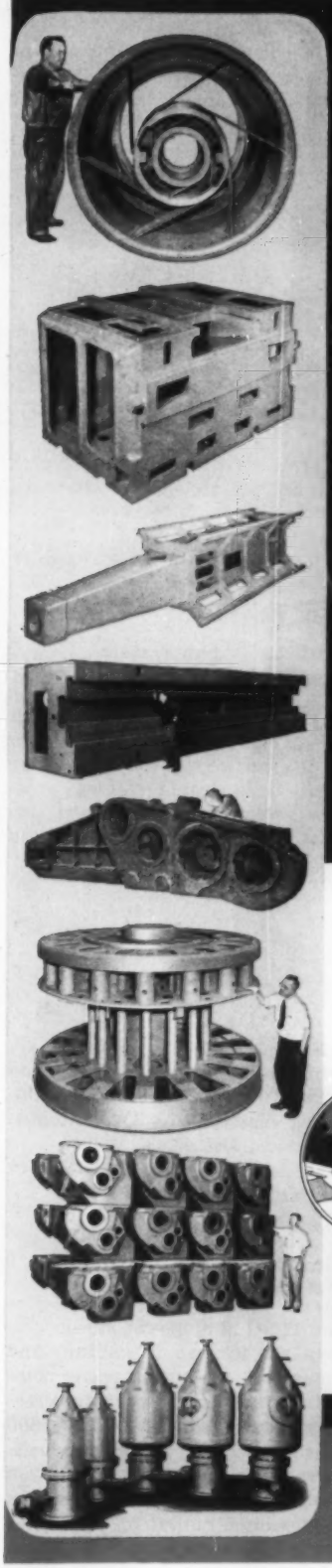
Speed Reducers

in double and triple-reduction stages

StraitLine reducers, providing complete interchangeability of in-

Steel-Weld FABRICATION





Use WELDED STEEL for Greater Strength with Less Weight!

The weldment shown above is one half of the base for a 300,000 KW Steam Turbine...it weighs over 100 tons. This base, and the units shown at left, are typical of the thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon each year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Are you taking full advantage of the economies offered by welded steel components in your products? In the design of almost any type of heavy machinery, or mechanical engineering project, there are parts and subassemblies that can be produced more economically and more satisfactorily in welded steel . . . because, in weldments you get greater strength with less weight, plus the additional advantages of greater rigidity and 100% predictability. When you consider weldments, you will want to discuss your requirements with Mahon engineers, because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill is backed-up by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

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Sales-Engineering Offices in Detroit, New York and Chicago

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The
TIMER RELAY
that handles all controlled timing problems . . .

★ No false contacts
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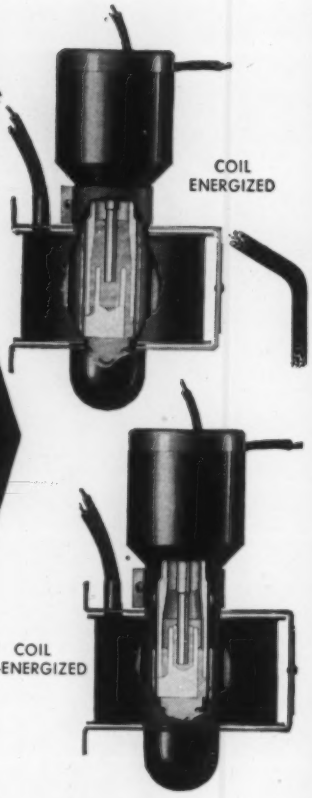
★ Low cost timer

Durakool®
STEEL MERCURY TIMERS



This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.

See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

Circle 516 on page 19

H.O. Boehme, Inc.
Designers and Manufacturers Communication Equipment
Precision Electro-Mechanical Apparatus
915 Broadway • New York 10, N.Y.

HOB

Circle 517 on page 19

New Parts

dividual parts, are available in double and triple-reduction stages. Double-reduction units are offered in 15 standard ratios from 3.39:1 to 57.3:1 with ratings to 100 hp. Triple-reduction units are available

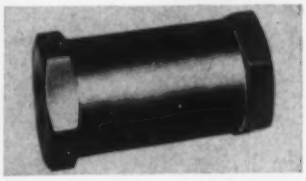
in 9 ratios from 82.1:1 to 190.7:1 with ratings to 50 hp. **Western Gear Corp.**, P. O. Box 182, Lynwood, Calif.

Circle 753 on page 19

Check Valve

withstands temperatures to 175 F

Aluminum check valve which weighs only 4 oz is available in two models for ½ and ⅜-in. pipe sizes. Differential cracking pressure is 1 psi maximum, and differential sealing pressure is less



than 1 psi. Unit withstands operating pressures to 125 psig and temperatures to 175 F. **Ross Operating Valve Co.**, 120 E. Golden Gate Ave., Detroit 3, Mich.

Circle 754 on page 19

Silicon Rectifiers

provide 600 ma output at 150 C

Four 170-C stud-mount silicon rectifiers are for use in military and commercial equipment power supplies. They have peak inverse-voltage ratings of 100, 200, 300 and 400 v with maximum rms voltage ratings of 70, 140, 210 and 280 v respectively. Units are designed for maximum output of 600 ma at case temperature of 150 C. Maxi-

"PONY POWER" MOTORS

that give stamina to your products

Lamb Electric ***fractional*** horsepower motors, like the small horses of the famed western-pioneer-day Pony Express, are developed for *stamina.*

Their dependability, and efficiency (optimum weight-size-horsepower ratio) are qualities that result from proper design and careful manufacture by personnel with many years of experience in the small motor field.

May we demonstrate how Lamb Electric Motors can bring these advantages—and also perhaps lower costs—to *your* products?

THE LAMB ELECTRIC COMPANY • KENT, OHIO

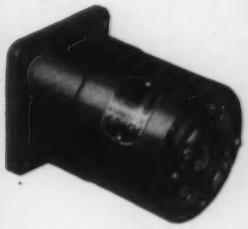
A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

A rugged high-torque, high-speed motor.



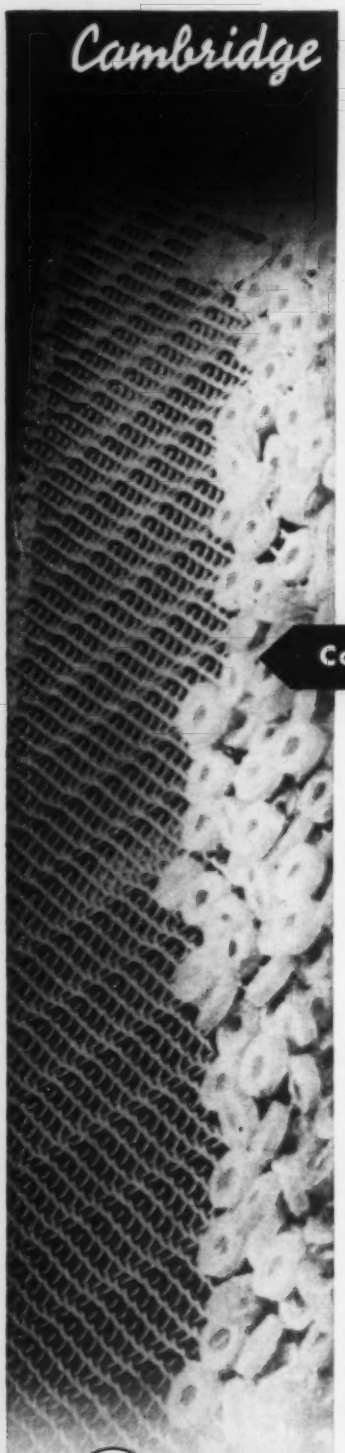
Radar voltage regulator gear motor.

Motor with efficient spur gear speed reducer.

Motor for high-speed grinder.

If you are interested in any of the above motors write and we shall be glad to send full information.

Circle 518 on page 19



Cambridge

Woven Wire Belts give you fast, economical processing

Using woven wire conveyor belts to move products through all phases of your manufacturing operation helps speed processing and cuts costly batch handling. Food products, chemicals, plastics, metal parts, ceramics or glass can be treated faster and easier with a continuous belt-to-belt flow through the plant on woven wire belts. Controlled belt speeds through any type of operation . . . hot or cold, wet or dry . . . help increase product uniformity and maintain capacity production. EXAMPLE:

Continuous Cooling

MOVING BELT carries hot candy through cooling tunnel in a steady stream. Free circulation of air through open mesh speeds cooling process.

ALL METAL BELT cannot absorb odors . . . remains unaffected by processing solutions, 2100°F. or sub-zero temperatures . . . gives longer life because there are no seams, lacers or fasteners to weaken or break. Rust-proof alloys maintain sanitary requirements.

OPEN MESH also provides free circulation of heat or cold, free drainage of process solutions. Broken bits or chips of the product fall through the open mesh to maintain product uniformity.

SPECIAL RAISED EDGES or surface attachments are available to hold products on belt during inclined travel.

Cambridge Woven Wire Conveyor Belts are a practical and economical means of combining movement with processing in any type of industry . . . food, chemical, metalworking, glass or ceramics . . . on all types of machines for your own operation or for resale. Cambridge Woven Wire Conveyor Belts are made in any size, mesh or weave, from any metal or alloy to do the job you want . . . hot or cold, wet or dry. Call your Cambridge Field Engineer to discuss how you can get fast, economical processing with woven wire conveyor belts. Look under "Belting, Mechanical" in the *Yellow Pages*. Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

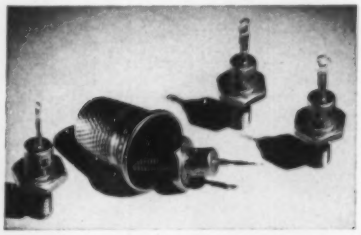
WIRE CLOTH | WOVEN WIRE CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

Department N, Cambridge 6, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

New Parts

mum allowable dc output current rating is 1.5 amp at 85 C. Maximum operating frequency is 100 kc. Rectifiers have No. 10-32 stud for direct chassis mounting, and are housed in a welded, all-metal



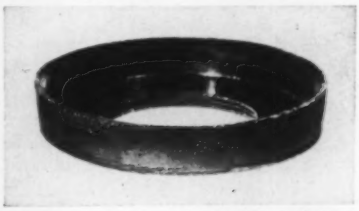
case. They meet military mechanical specifications. **General Electric Co.,** Semiconductor Products, Electronic Park, Syracuse, N. Y.

Circle 755 on page 19

Cup Packing

of synthetic rubber

Fabricated synthetic-rubber cup packing, designated No. 3081, is for air, water and oil service with temperatures to 250 F. High-density synthetic rubber completely and uniformly covers fabric layers in the packing. Available in standard sizes up to 6¾ in. OD, packing is preshaped to prevent distortion under pressure. Silicone lubri-



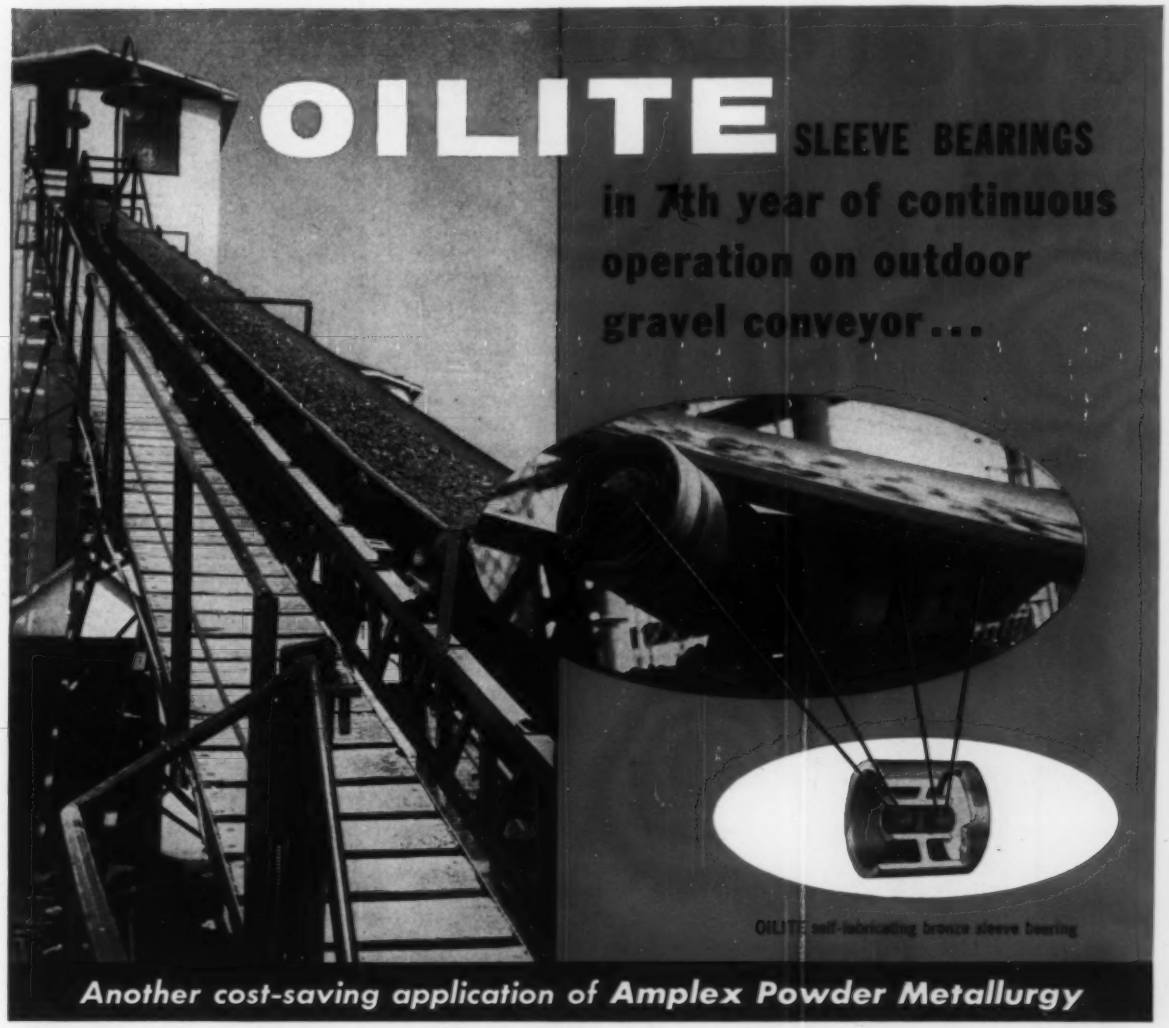
cant assures easy installation and break-in. **E. F. Houghton & Co.,** 303 W. Lehigh Ave., Philadelphia 33, Pa.

Circle 756 on page 19

Tilting Motor Base

for all fractional-hp motors

Compact tilting motor base does double duty with any variable-speed pulley. Base compensates for belt tension when speed changes are made while machine is running. Unit base is one size for all fractional-hp motors. Correct belt tension and alignment


OILITE SLEEVE BEARINGS
in 7th year of continuous operation on outdoor gravel conveyor...
OILITE self-lubricating bronze sleeve bearing
Another cost-saving application of Amplex Powder Metallurgy

No seals protect these OILITE bearings from sand, gravel, grit. On the two center rollers, no additional lubrication is possible. Yet this OILITE-equipped outdoor conveyor has been in continuous operation under extreme weather conditions for seven years—*without replacing one OILITE bearing.*

That's some record! J. Cooke (Concrete Blocks) Ltd., of Aldershot, Ontario, one of Canada's largest producers of concrete blocks, operating twenty of these sand and gravel conveyors, has proved the long wearing, money saving qualities of OILITE bearings. No wonder all twenty conveyors are 100% OILITE equipped. The company says, "We wouldn't use any other kind."

What interests you? Longer product life—greater efficiency—lower cost? All three? Maybe Amplex has the answer.

Write for detailed information about Amplex powder metal components—OILITE Bearings, Parts, Filters. Or call your nearest engineering representative listed in the yellow pages under "Bearings—OILITE."

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HEAT & DIRT ESCAPE

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Automotive Spring Loaded

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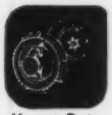
Oil or Dry Multiple Disc


Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

Nine large ports in the sides and twenty-one holes in the top of this ROCKFORD Spring-Loaded CLUTCH cover provide increased ventilation during operation under adverse conditions. Extreme heat, generated by modern high-speed engines, is dissipated—to prevent burning and warping. Dirt, grease and moisture, encountered in off-highway operations, are carried away —to avoid excessive clutch wear.

Learn how this and other recent improvements in ROCKFORD CLUTCHES will help *your* products meet changes in modern operating conditions.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

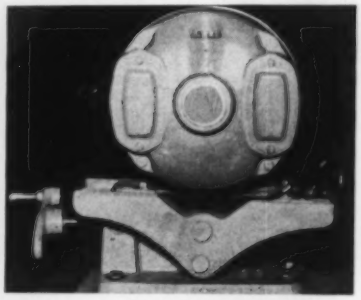
311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ENGINEERING B-W PRODUCTION

CLUTCHES

New Parts



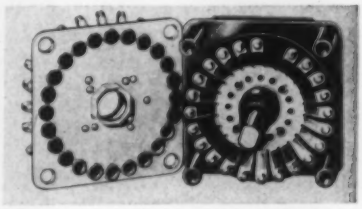
are maintained by a handwheel screw adjustment which changes angle of tilt. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake St., Chicago 44, Ill.

Circle 757 on page 19

Miniature Switch

is cluster-arm type

Miniature switch is used for ammeter and voltmeter switching, capacitance decades, sequential load substitution, and sequential ac or dc power substitution. Unit has a multifinger silver-alloy cluster arm attached to the rotor. Cluster-arm switch assemblies can be ganged



with conventional decks. Basic 24 or 32-finger cluster assembly is supplied in varying configurations to suit any requirement. **Shallcross Mfg. Co.**, Collingdale, Pa.

Circle 758 on page 19

Throttling Valves

adapt to a variety of installations

Precision throttling valves are for use with oils, fuels and other liquids compatible with aluminum and steel in central hydraulic systems, missiles systems, aircraft and marine applications, and in test equipment. Available with female pipe thread, female brazed tube fitting and JIC threaded parts, valves feature low torque. Two, 1½ and 1¼-in. ported flanges are adaptable to one basic body size; and 1, ¾, ½,

another VALVAIR *first...*

NEW SPEED KING PLUG-IN CONTROL VALVES

Compare ... and you'll buy

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LEADERSHIP...

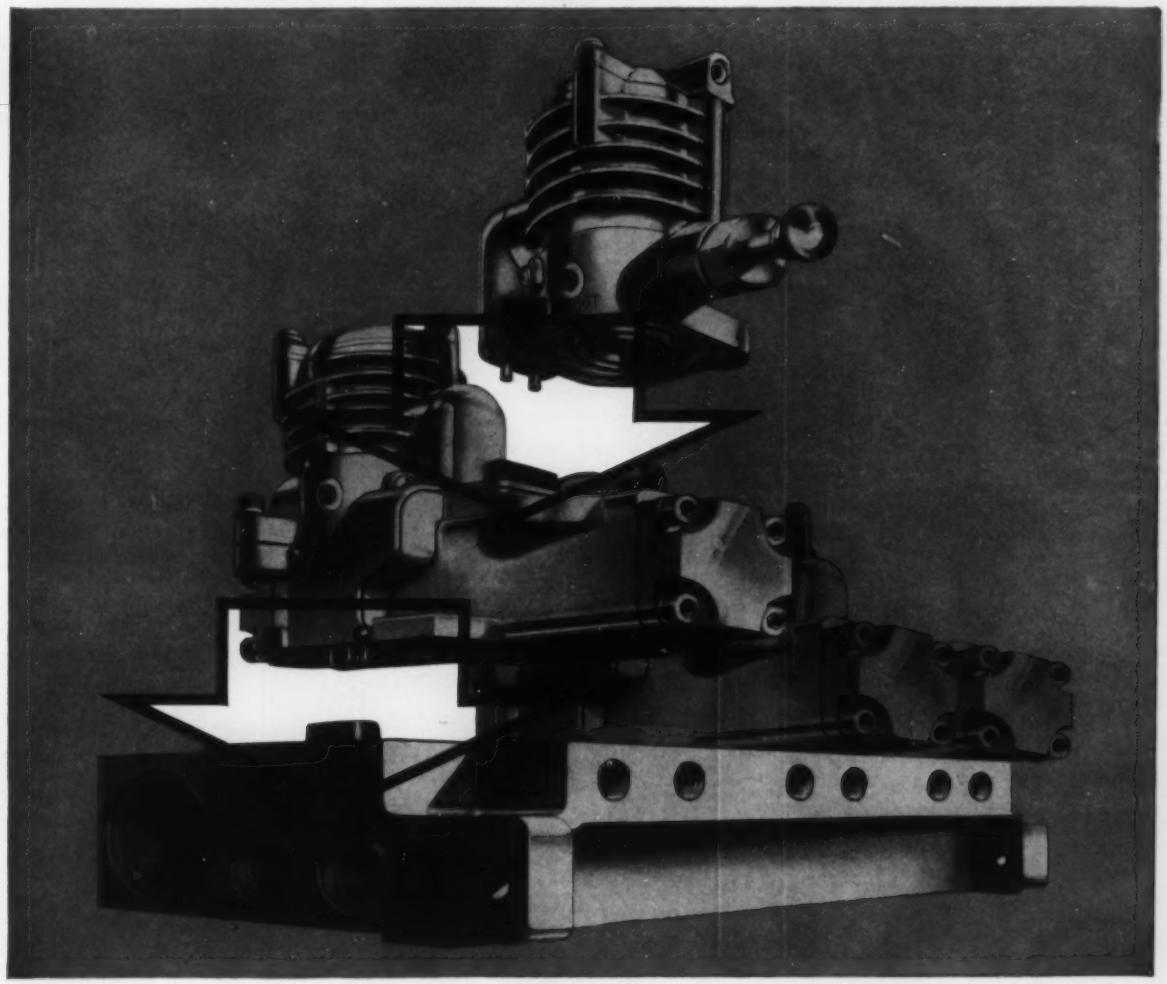
Representatives in principal cities

Valvair's new Speed King ¼ in., 4-way control valves have built-in plugs and connectors—complete electrical connections automatically! All connections are made in manifold or sub-base—valves simply bolt in place. Pilots plug in, too, for fastest in-service maintenance!

And, compact size, peak performance plus multi-million cycle dependability, assured by aluminum and stainless steel components . . . coil guaranteed against burn-out for life of valve . . . manifold, sub-base or foot mounting—single or double solenoid . . . JIC pilots . . . 35—200 psi range . . . ¼ in. NPT ports . . . coils for ac or dc, any voltage . . . optional manual over-ride . . . all are yours with ¼ in. Speed Kings!

Put these advanced-design valves to work on your machines . . . their performance and economy will amaze you! Valvair Corporation, 454 Morgan Ave., Akron, Ohio. AA-5898

Multiple manifold mounting; 3 station shown, 2 station available. Conduit port, 1¼ in. NPT; common inlet and exhaust ports, ½ in. NPT; cylinder ports, ¼ in. NPT. Manifolds may be ganged for installation of any number of valves. Sub-base and foot-mounted valves also offered.



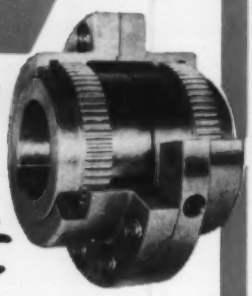
Waldron couplings on a fan drive of jacket water coolers.

by specifying

WALDRON

Gear Couplings

you get



STRENGTH — Hubs and cover sleeves for sizes 1¼ A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

RELIABILITY — There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is positioned where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

SERVICE — Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

▶ Ask for Catalog 57

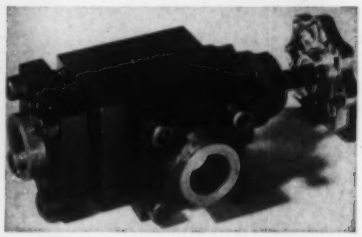
JOHN **WALDRON** CORP.

NEW BRUNSWICK, NEW JERSEY

Representatives In Principal Cities

New Parts

⅜ and ¼-in. ported flanges adapt to another size. Two hundred and sixty-eight combinations of porting can be accomplished with larger body, 400 combinations with the



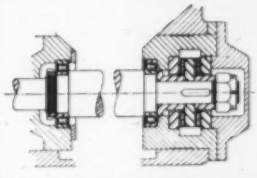
smaller. Valve seat replacement is accomplished without removing body from line. **Greer Hydraulics Inc.**, Products Div., New York International Airport, Jamaica 30, N.Y.

Circle 759 on page 19

Thrust Bearing

for gear-reduction units

Double-acting thrust bearing, designed to withstand extremely heavy thrust loads in either direction, is for use in gear-reduction units. A flat-seat type bearing with 2-in. bore and 6 3/16-in. OD, it consists of center plate, two roller assemblies, two stationary plates, and two rotating inner



sleeves. Thrust capacity is 17,550 lb at 750 rpm. **Rollway Bearing Co.**, 541 Seymour St., Syracuse, N.Y.

Circle 760 on page 19

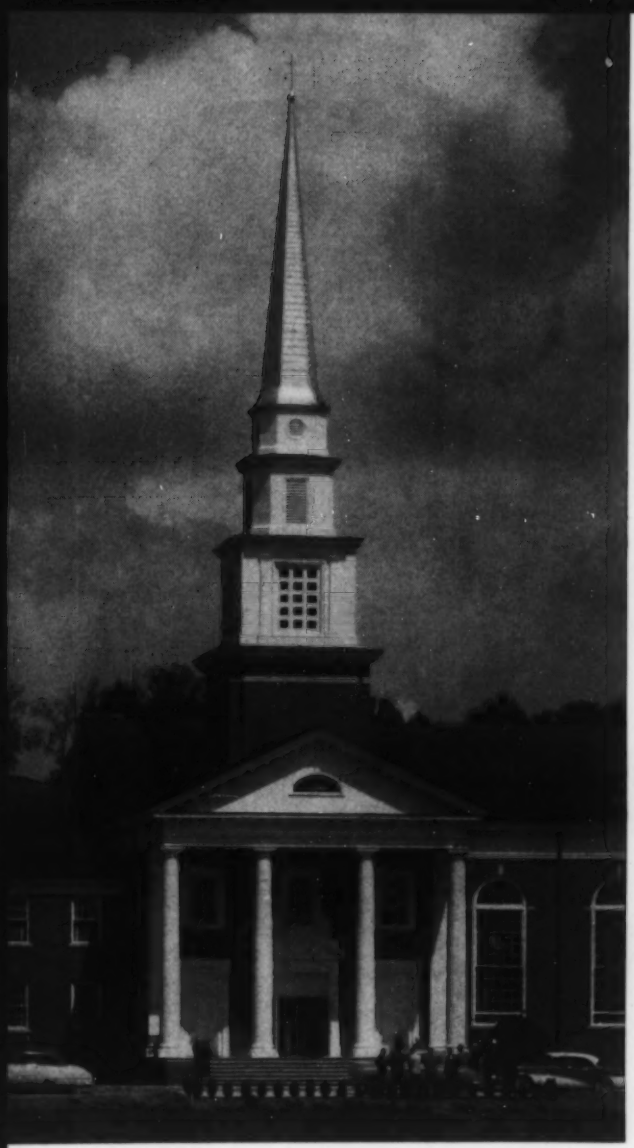
Hermetically-Sealed Coils

in nonflammable ceramic cases

Inductance coils housed in hermetically-sealed ceramic cases are particularly suited for close-tolerance inductance requirements under severe operating conditions. Coils are housed in cylindrical casing of nonflammable and moistureproof steatite, which is also fungusproof. Circular steatite end plates are

Circle 523 on page 19

Circle 524 on page 19→



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Stainless Steel

in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

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PIPE • TUBES • WIRE • SPECIAL SECTIONS

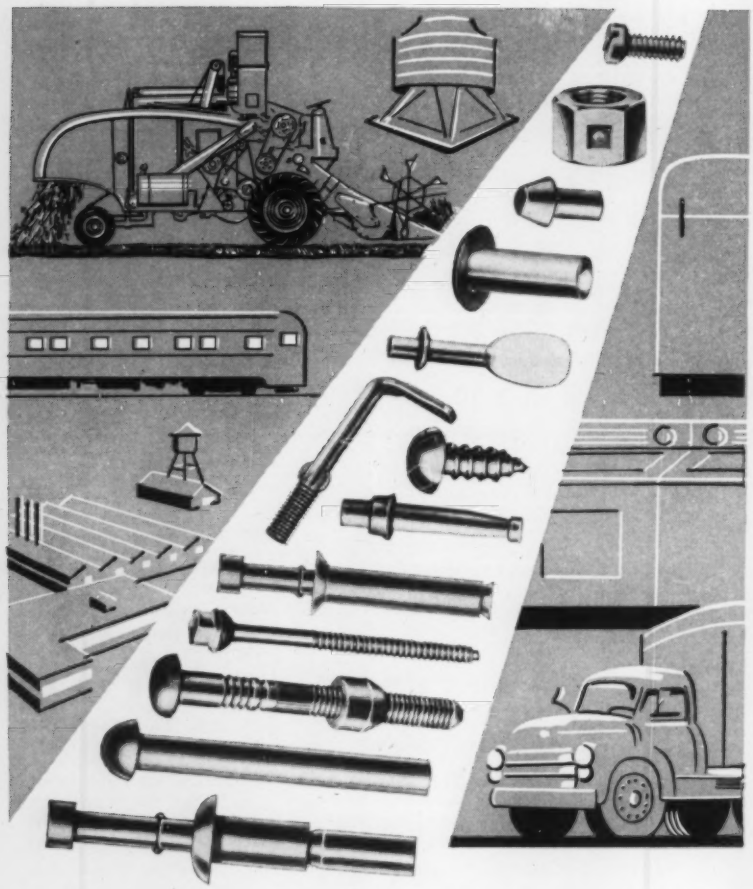
USS

UNITED STATES STEEL

FOR BEAUTY. Stainless Steel shingles in diminishing sizes create a beautiful, gleaming steeple for the State Street Methodist Church in Bristol, Virginia. Architect Allen Dryden, of Kingsport, Tenn., specifies Stainless Steel for jobs like this to assure lasting beauty, protection from weather and freedom from maintenance. This spire is sheathed in Type 302 26-gage Stainless Steel, and the cross is built of Type 302 Stainless bars. Construction details were engineered by Overly Manufacturing Company, Greensburg, Pa., who also fabricated and erected the steeple.

FOR FLEXIBILITY OF DESIGN. In this "Cold-Zone" cooling-storage milk products tank, made by Damrow Brothers Company, Fond du Lac, Wisc., Type 304 10-gage Stainless Steel was used for the smooth, easy-to-clean inner wall. Again Stainless Steel—this time Type 304 16-gage—was used for the dimpled outer wall which is stave-welded to the inner shell. This unusual design of dimple size and arrangement gives proper baffling and velocity to the refrigerant as it passes through the cooling area. Stainless Steel provides greater sanitation, durability, long life, strength and—the flexibility necessary to make this design possible.

FOR DURABILITY. The Master Combination Padlock, designed for school locker room use and built by Master Lock Company, Milwaukee, Wisconsin, features a double-case construction—with Type 430 Stainless Steel used for the outer case. This Stainless Steel design makes it one of the strongest padlocks available. In addition to increasing the lock's durability, Stainless Steel also adds to its sales appeal and to its resistance to the corrosive atmospheres of damp locker rooms. The springs, too, are made from USS Stainless Steel—Type 304 Ameroxide coated wire.



There is an application on your product where Townsend fasteners can save you money

Your products can be improved, and your manufacturing costs reduced, by using Townsend cold-formed fasteners and special parts. Townsend makes many types, and each is available in a variety of sizes and materials. Whatever your problem, there is a Townsend product which will provide a solution. If none of the thousands of standard items have the desired properties, a special part will be designed.

Cold-formed parts by Townsend are facilitating design improvements and reducing assembly costs in automotive, appliance, farm equipment, railroad rolling stock, and innumerable other manufacturing industries. In addition, they are providing low-cost, high-strength joints in all types of construction work. If you would like to learn what Townsend cold-formed fasteners and special parts can do to improve your products and production, write to Townsend Company, P.O. Box 237-E, New Brighton, Pennsylvania.

The Fastening Authority

Townsend

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NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

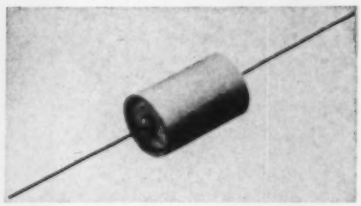
Cherry Rivet Division • Santa Ana, California

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

Circle 525 on page 19

New Parts

sealed to housing with epoxy-filler combination, with sealing material isolated from lead wires. Housing is vacuum-filled with microcrystalline wax before sealing. Tests of the coils show an insulation resist-



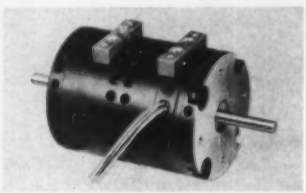
ance of 500,000 megohms. Temperatures from −55 to 105 C produce no changes in housing or end seal. **Speer Carbon Co.**, St. Marys, Pa.

Circle 761 on page 19

High-Frequency Motor

has double-end shaft

Type A 400-cycle ac motor with double-end shaft drives a double turbine wheel on aircraft heat exchangers. It has two-way ventilation for high self-cooling characteristics, and delivers 1/3-hp continuously up to 50,000 ft altitude. Of induction type, the motor op-



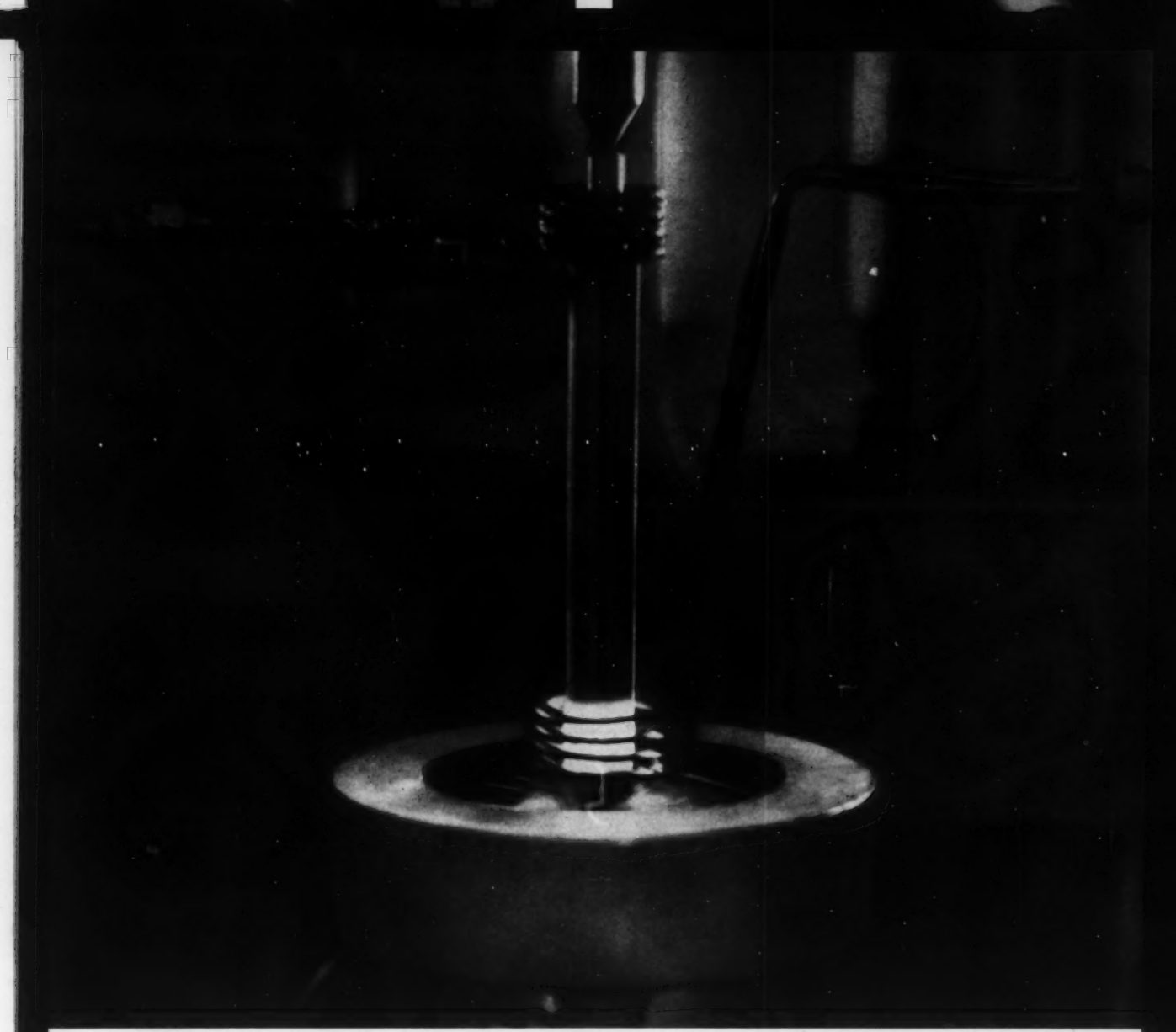
erates at 5600 rpm on three-phase, 400-cycle, 200-v ac. Weight is only 4½ lb. Mounting flanges located at each end provide direct connection to driven equipment. **U. S. Electrical Motors Inc.**, Box 2058, Terminal Annex, Los Angeles 54, Calif.

Circle 762 on page 19

Miniature Connectors

for high-altitude flight operations

Miniature high-temperature electrical connectors, designed for high-altitude flight operation, have staggered construction which gives long creepage path between pins. Body is corrosion-resistant ano-



Ketos shaft being induction hardened to Rockwell 55-56, while ends remain soft for final machining. Photographed at Control Instrument Co., Inc., Brooklyn, N. Y.

KETOS has wide hardening range with minimum volume change...

Ketos is a low priced alloy tool steel that can be hardened from low temperatures with practically no volume change. It has deep hardening qualities, and a fine grained structure, that make it desirable for many production parts.

That's why nondeforming Ketos is well suited not only for most tool steel applications such as gauges, dies, and taps but also for close-tolerance, wear-resistant parts like the actuator bar shown in the induction heating unit above. The thin contact edges of this particular part withstood a "life test" of over 4-million high speed blows. No other steel tested lasted more than 1-million cycles before it chipped and failed.

If Ketos sounds like the steel you should be using, call your nearby Crucible warehouse. Stocks of Ketos and dozens of other special tool steels are large, delivery fast. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

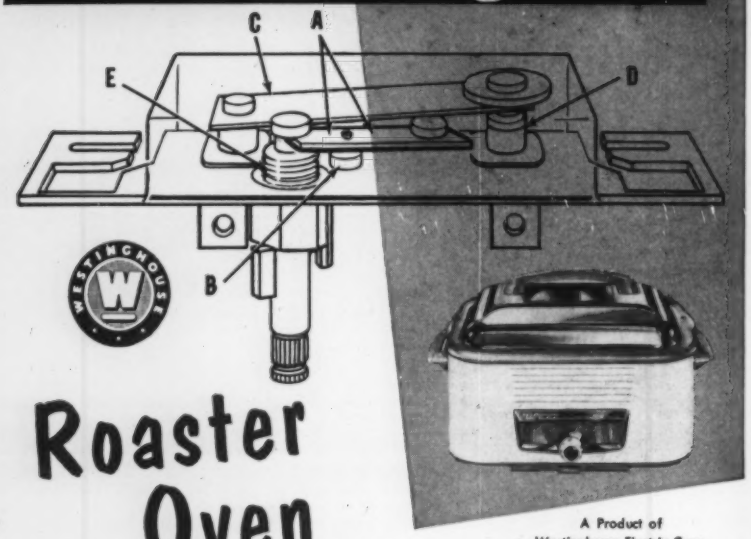
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

Circle 526 on page 19

HOW CHACE THERMOSTATIC BIMETAL CONTROLS THE Westinghouse



Roaster Oven

A Product of
Westinghouse Electric Corp.
Mansfield, Ohio

A versatile servant is the new Westinghouse Electric Roaster-Oven which can be used to bake anything from a 14 lb. turkey to a complete oven meal. With its accessory, the broiler grid, it also can be used for broiling, grilling and frying. Of course, the actuating element in this modern appliance is reliable Chace Thermostatic Bimetal.

Here's how it works: The thermostatic bimetal element (A) is mounted freely on the fulcrum pin (B), in a position exposed to radiation from the roaster heating element. The current is carried by the leaf spring (C) through the contacts (D). As the ambient temperature in the roaster increases, the bimetal element (A) deflects in the direction of the spring (C), until the insulated tip presses against the spring and opens the contacts (D). The temperature then drops, the bimetal returns, the contacts meet and this cycle repeats. Since the notched end of the bimetal element is engaged in the groove in the threaded stem (E), turning the control knob clockwise moves the bimetal away from the spring, thus prolonging the contact time and raising the cooking range.

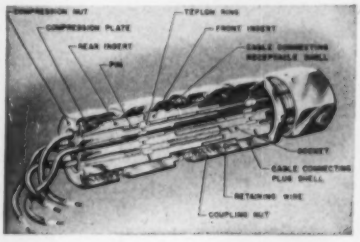
Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Circle 527 on page 19

New Parts

dized aluminum. Each pin of the mated connector is surrounded by Teflon. Three types of receptacles and a matching plug to fit all three are available. Series 100 is a square-flange receptacle, Series 200 is a panel-mount type, and



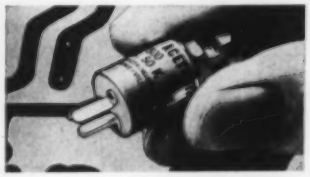
Series 300 is a cord receptacle. Available with 1, 3, 7 or 19 pins, connectors are rated 1800 v ac at sea level and 800 v ac at 70,000 ft. They withstand shock of 200 g. Operational temperature range is −67 to 400 F. **Consolidated Electrodynamics Corp.**, Glendale Div., 740 Salem, Glendale, Calif.

Circle 763 on page 19

Subminiature Potentiometers

for printed-circuit applications

Acetrim precision wire - wound trimming potentiometers have round or flat tabs in place of terminals to facilitate assembly with other printed - circuit elements. Units operate at temperatures



from −55 to 125 C. They are sealed, moistureproofed and antifungus treated, withstand severe shock, vibration and acceleration, and meet applicable military specifications. **Ace Electronics Associates Inc.**, 103 Dover St., Somerville 44, Mass.

Circle 764 on page 19

Neoprene-Impeller Pump

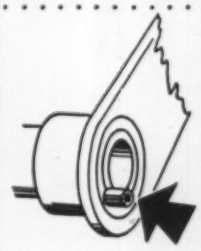
low-pressure unit is self-priming

K ½ Special pump is self-priming and operates quietly in either di-

Circle 528 on page 19→

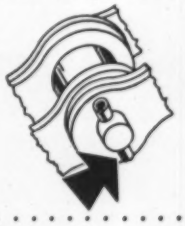
Rollpin® replaces 12 different fasteners

REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a stop pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.



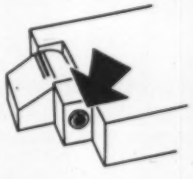
REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.

REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.

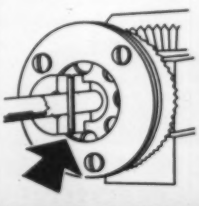


REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.

REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.

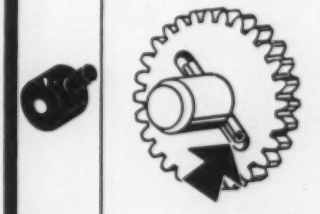


REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.

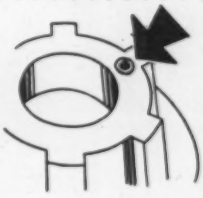


REPLACING TAPER PINS . . . in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.

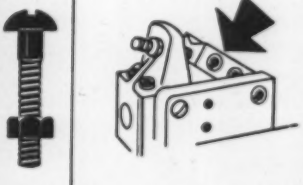
REPLACING A HEADED PIN . . . in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.



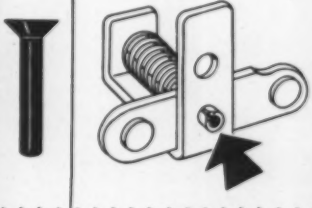
REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



REPLACING A DOWEL PIN . . . Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.



REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

WHERE CAN YOU USE THIS SIMPLE FASTENER?

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R47-64, Union, New Jersey.

ROLLPIN TRADEMARK

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 VAUXHALL ROAD, UNION, NEW JERSEY

NEW CONTROLLER LINE ADAPTS 576 WAYS

Fenwal Announces Low-Cost Temperature Indicating Controllers

ASHLAND, MASS. — Fenwal Inc., has announced here that tailor-made, accurate, low-cost temperature indicating controllers are now available from stock.

Tailor-mades from stock are made possible by the development of the new Fenwal Series 541 line. The Series 541 is a standardized line of matched temperature indicating controller parts which can be combined easily in 576 ways.

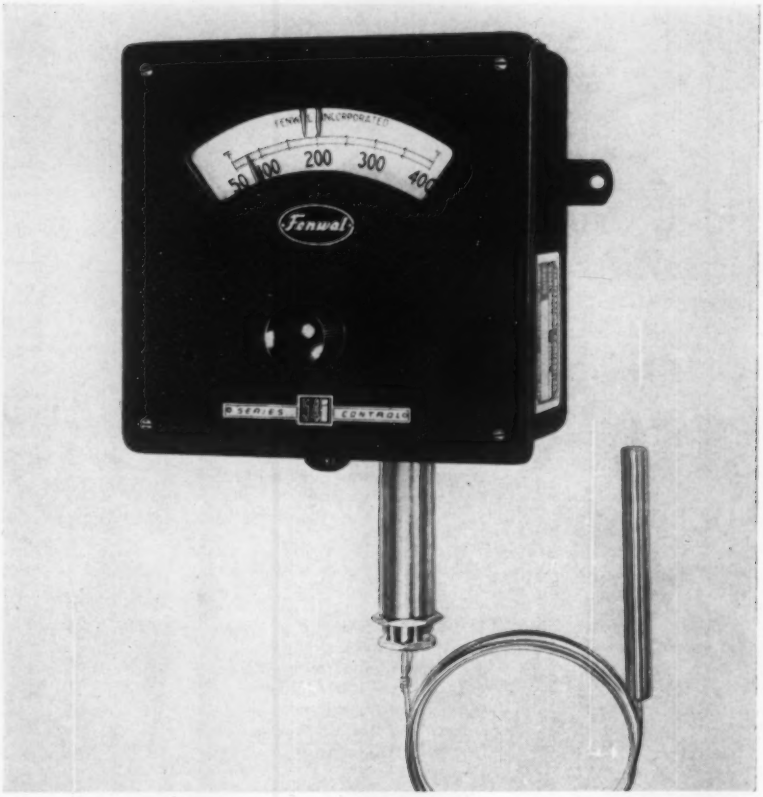
From these possible combinations come perfect solutions to countless temperature control problems. A prospective user lists the characteristics of the ideal temperature indicating controller for his particular operation, and Fenwal assembles an instrument with those characteristics from parts in stock.

No matter what combination is chosen, the result is a rugged, accurate, compact and easily maintained unit in a shock-proof, splash-proof, dust-proof housing. The housing is available in colors to match any equipment in which it may be installed.

Installation and calibration are so simple that instrument technicians and laboratory procedures are unnecessary. And, after installation, all normal temperature adjustments are external.

No matter what combination is chosen, the resulting instrument is accurate to within one per cent of scale. The accuracy is long lasting, with few moving parts and no internal gears. Simplicity of design brings the wear factor close to zero.

Series 541 offers single or double circuit control. There is a choice of four different long-life snap switches, with ratings up to 20 amps, 250 volts, A.C. These switches, singly or in combination, can provide a wide variety of operating characteristics.



One of Fenwal's new Series 541, bulb-and-capillary controllers. Photo shows dual circuit model which has two snap switches, each with a setpoint indicator, that actuate two separate circuits at the pre-set temperatures.

Three stainless steel bulb types are available at no increase in price to meet space or process requirements. Capillaries and bulbs are corrosion-proof. Capillaries are swivel-mounted to protect them from breakage.

There is a choice of three temperature ranges: −150° to 200°F, 50° to 400°F, or 50° to 700°F, or their centigrade equivalents. Special ranges are available on request.

The control mechanism may be subjected to temperatures up to 150°F, and is ambient compensated from 50° to 150°F.

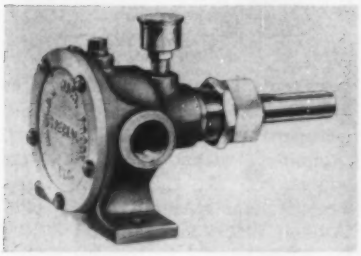
Write to Fenwal Incorporated, 197 Pleasant Street, Ashland, Mass. Describe the tailor-made temperature indicating controller that would fit your operation perfectly. Chances are excellent that the tailor-made can be yours — at savings never before possible.

Fenwal

CONTROLS TEMPERATURE
. . . PRECISELY

Circle 529 on page 19

rection at low or high speeds. It has a neoprene impeller, and operates off a motor as small as 1/3-hp, single phase. It handles all liquids that do not affect bronze or neoprene, at 7½ gpm, 10 psi at 1750 rpm. Unit is designed for



general transfer of liquids at low pressure, such as in home laundries, sump drainage, for coolants, air conditioners and refrigeration. **American Machine Products Inc.**, 172 Centre St., New York 13, N. Y.

Circle 765 on page 19

Silicone Resin

for high-temperature coatings

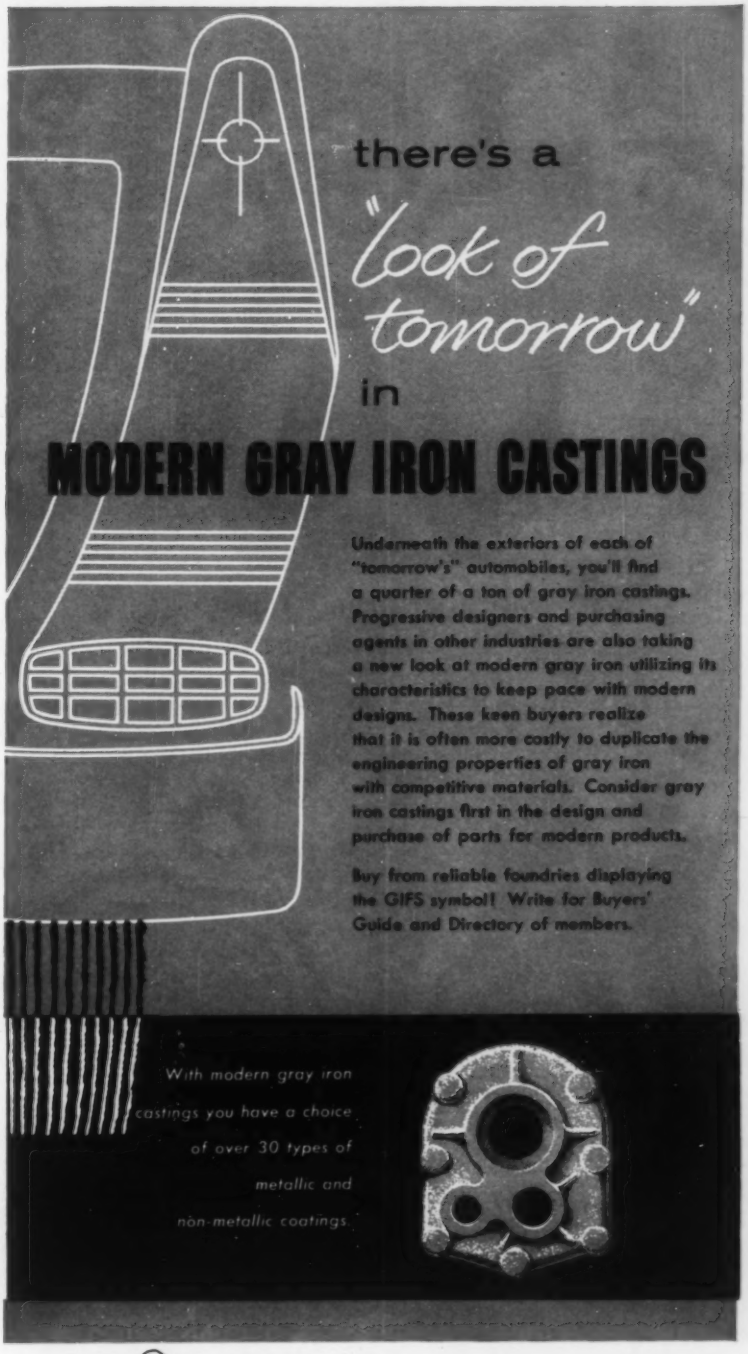
Silicone resin, designated 808, provides excellent high-temperature protective and decorative coatings. Developed primarily for use in formulating white and light-colored space-heater and appliance finishes, it provides greater gloss retention after long exposure to high temperatures than previously possible. Material is nonyellowing and exhibits excellent adhesion, flexibility and resistance to moisture and many common chemicals. **Dow Corning Corp.**, Midland, Mich.

Circle 766 on page 19

Summation Amplifier

for computer applications

Single-channel, transistorized Model 807 amplifier is designed for use as an isolation amplifier with any standard 400-cps resolver (Mach 4 Mod 0 or equivalent). It provides compensation for phase-shift errors and nonlinearities caused by inductance and reactance of resolver systems. Unit offers high impedance to driving resolver and low impedance to driven resolver. With operating life of over 8000 hr and accuracy of more than ±0.1


there's a
"look of tomorrow"
in
MODERN GRAY IRON CASTINGS
Underneath the exteriors of each of "tomorrow's" automobiles, you'll find a quarter of a ton of gray iron castings. Progressive designers and purchasing agents in other industries are also taking a new look at modern gray iron utilizing its characteristics to keep pace with modern designs. These keen buyers realize that it is often more costly to duplicate the engineering properties of gray iron with competitive materials. Consider gray iron castings first in the design and purchase of parts for modern products.
Buy from reliable foundries displaying the GIFS symbol! Write for Buyers' Guide and Directory of members.
With modern gray iron castings you have a choice of over 30 types of metallic and non-metallic coatings

it's time to design with

GRAY IRON CASTINGS

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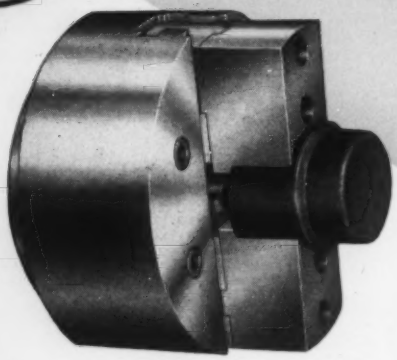
Circle 530 on page 19

POWER CHUCKS



for more gripping power– higher production

Famous S-P cam and lever design holds the work tighter, permits cost cutting heavy feeds and multiple cuts. S-P cam and lever design also resists opening of jaws by centrifugal force or diminishing air pressure . . . an important safety factor. Balanced for high rpm.

S-P SELF-CENTERING CHUCKS are built in Universal American Standard models, sizes 6" – 8" – 10" – 12", and Serrated models in 8" – 10" – 12" sizes. Two or three jaws.

S-P COMPENSATING CHUCKS grip out-of-round work with equal pressure on each jaw. Available in 8" – 10" – 12" sizes, two and three jaw models, American Standard or Serrated.

S-P ROTATING CYLINDERS

Air and Hydraulic

Adequate stroke for long jaw travel of S-P Chucks. Balanced for high rpm on machine tools and other applications. Details in Catalog No. 105 (Air) and Bul. 201 (Hydraulic).

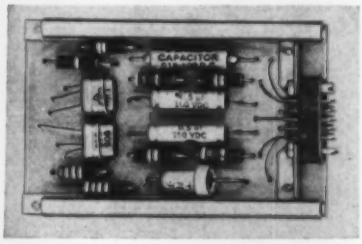
S-P Power Chucks are installed as original equipment by Bardons & Oliver, Cleveland Automatic, Cone Automatic, Ex-Cell-O, Jones & Lamson, Monarch, Warner & Swasey . . . and many others. Representatives in principal cities. Prompt deliveries. Send for catalog No. 105. The S-P Manufacturing Corporation, 30201 Aurora Rd., Solon, Ohio.

SPecify SP

THE S-P MANUFACTURING CORP.
SOLON, OHIO • IN GREATER CLEVELAND
ESTABLISHED 1916 A BASSETT-COMPANY

NON-ROTATING AIR AND HYDRAULIC CYLINDERS • ROTATING AIR AND HYDRAULIC CYLINDERS
POWER CHUCKS • COLLET AND DRILL PRESS CHUCKS • AIR PISTONS, VALVES, ACCESSORIES

New Parts



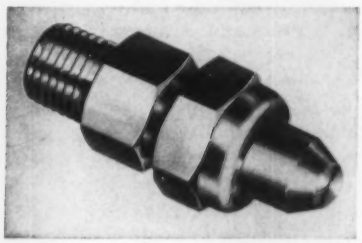
per cent, it holds phase-shift errors to less than 0.15-deg. Temperature range is −55 to 85 C. Amplifier withstands shock and vibration. **W. L. Maxson Corp.**, Maxson Instruments Div., 47-37 Austell Place, Long Island City 1, N. Y.

Circle 767 on page 19

Spray Nozzles

small capacity units in 12 styles

Full Cone spray nozzles provide extremely small capacities and atomization using hydraulic pressure. Twelve nozzles are available, in both male and female pipe connections, in capacities ranging from 0.042 to 1.400 gpm at 20 psi.



Spray pattern of the nozzle is uniform in distribution. Spray angle ranges from 50 to 67 deg as capacity increases. **Spraying Systems Co.**, Randolph St., Bellwood, Ill.

Circle 768 on page 19

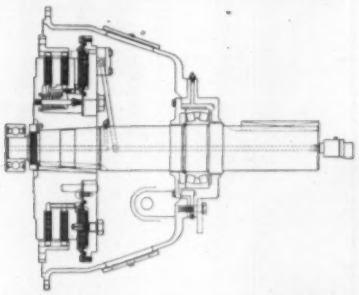
Power Take-Off

for engines with up to 600 hp output

Air - operated, remote - controlled friction-power take-off is available for engines up to 600 hp output in industrial applications where standard power take-off is used. It combines air clutch with standard friction power take-off. Engagement and disengagement is accomplished by turning an air valve. Rotary seal, added to end

Circle 531 on page 19

of output shaft, permits actuating air to enter clutch through drilled passage in shaft. Unit is built to



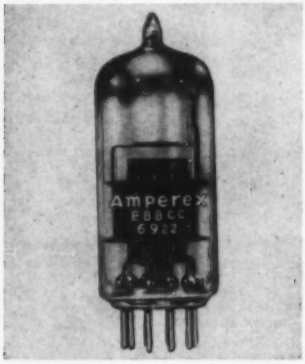
SAE design standards. **Twin Disc Clutch Co.**, Racine, Wis.

Circle 769 on page 19

Miniature Twin Triode

has long life and high transconductance

Type E88CC/6922 frame - grid miniature twin triode is used in cascade circuits, HF and IF amplifiers, mixer and phase-inverter stages, and as a multivibrator and cathode follower in computers. It has a separate cathode for each triode section. Unit exhibits ex-



tremely long life, high transconductance and low noise. **Amperex Electronic Corp.**, Special Purpose Tube Div., 230 Duffy Ave., Hicksville, L.I., N.Y.

Circle 770 on page 19

Plug and Seals

are expandable and reusable

Two basic types of quick-closing, fast-adjusting, reusable plugs are designed for use in pressure-testing of rough castings to eliminate

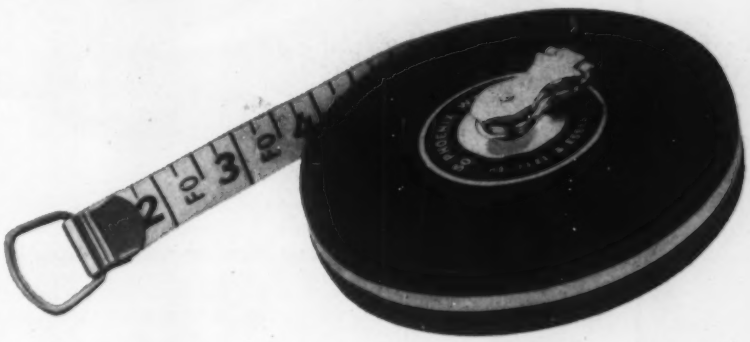
(*Continued on Page* 224)

ALBADURE*... the steel tape with lasting legibility

Here is a steel tape that stays clear and legible long after markings on other tapes have worn off.

An amazingly tough plastic coating on both sides of the line protects the white background, the graduations and numbers on ALBADURE tapes, giving their surfaces tremendous resistance to abrasion and corrosion. To quote a State surveying party report, "If ALBADURE stood up in this tough mud and sand, it'll stand up anywhere." Available in all standard lengths, widths and graduations, in cases and on reels.

PHOENIX WYTEFACE®... the woven tape that outlasts others 3-1



PHOENIX WYTEFACE (non-metallic) Woven Tapes made from extra strong synthetic yarns, are harder wearing, with higher tensile strength and dimensional stability than ordinary woven tapes. A special plastic coating on both sides protects the line against hard use, water, stones or brush.

The end of the line is enormously strengthened by a lamination of Flexi-Foam, a spongy plastic-rubber. No stitches or hinge point to weaken the line.

A Highway Engineer reported of the non-metallic PHOENIX WYTEFACE, "It has at least three times the life of an ordinary metallic tape." *Ask Your K & E Dealer!*

*Trade Mark

89 YEARS OF LEADERSHIP In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

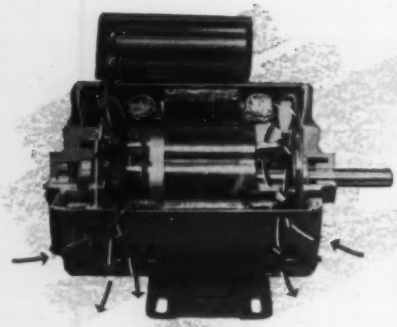
KEUFFEL & ESSER CO.

NEW YORK • HOBOKEN, N. J. • Detroit • Chicago • St. Louis • Dallas • San Francisco • Los Angeles • Seattle • Montreal

Circle 532 on page 19

available in . . .
SPLIT PHASE,
PERMANENT SPLIT CAPACITOR,
CAPACITOR START-INDUCTION RUN,
POLYPHASE

NEW!



VENTILATION

CLEAN, MODERN DESIGN—Lightweight, die-cast aluminum head ends accurately fit precision machined steel body, assuring rigidity and good alignment. External finish is smooth, flaw-free . . . blends well with any color.

IMPROVED, DOUBLE-END VENTILATION—Ventilating fans are integral with die-cast aluminum squirrel cage rotor, providing effective cooling of the windings from both ends for long life. Properly located openings give maximum cooling with minimum internal parts exposure.

MYLAR* POSITIVE INSULATION—Mylar* polyester film laminated to rag paper insulates slot cells and other strategic areas. Excellent dielectric qualities and resistance to tearing and aging, affording virtually permanent protection against dust, moisture and heat damage.

CHOICE OF MOUNTINGS, BEARINGS—Rigid, welded base or vibrationless, ultra-quiet resilient mounting with motor hubs floating on rubber cushioning rings permanently bonded to inner and outer metal bands. Either sleeve type or fully sealed ball bearings available. If desired, special construction permits re-lubrication of ball bearings. Bearings seat in precision bored steel rings cast into the aluminum heads.

**DuPont registered trademark*

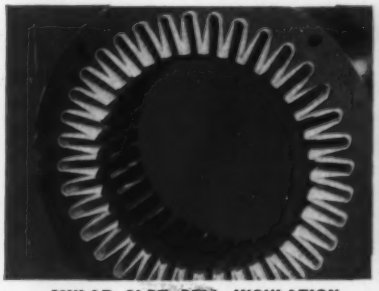
Robbins & Myers build motors
from 1/200 to 200 horsepower

R&M®

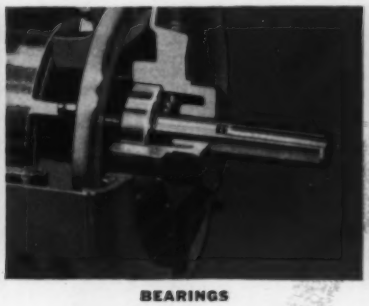
R & M's BROAD LINE OF SMALLER, LIGHTER, FRACTIONAL HP MOTORS

Robbins & Myers Re-Rated Frames 56 and 48

Here's a dynamic new motor—smaller, lighter, more versatile than older frame motors—yet with undiminished performance and reserve power. Completely new R&M "Model R" fractional horsepower motors will perform dependably and enhance the appearance and acceptability of your products. They range from 1 to ⅛ HP in types for all your applications: polyphase, permanent split capacitor, capacitor start single phase and (in the smaller ranges) split phase types. Designed in new NEMA frames 56 and 48, they are *lighter* due to new applications of aluminum, steel and copper . . . *smaller*, thanks largely to a unique new ventilating system . . . *more versatile* because of weight, size and many other design features involving frames, mountings, insulation etc. Look over the big advantages these motors offer you! Then write today for R&M Bulletin No. 450—MD.



MYLAR SLOT CELL INSULATION



BEARINGS

TtotALLY ENCLOSED—FAN COOLED

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

MOTORS FANS HOISTS MOYNO PUMPS PROPELLAIR FANS

LIVE BETTER ELECTRICALLY

PROMET

ENGINEERED
BRONZE BEARINGS
Wear Longer
or YOUR MONEY BACK!

So certain that the formula developed specifically for your bearings, bushings and wearing parts will be absolutely correct, American Crucible guarantees longer, trouble-free service or money refunded.

The customer's opinion is final.
Write for free literature and service data sheets or send prints and conditions of operation for recommendations and quotations. No obligation.

THE American Crucible PRODUCTS CO.

1321 Oberlin Avenue

Lorain, Ohio, U.S.A.

Circle 534 on page 19

Mozart was on the ball

No "square" was Mozart—his compositions keep rolling along through the years like Universal *Precision* Balls—the classically perfect balls with unlimited possibilities for designer and manufacturer. Available in a variety of materials—metallic or non-metallic—with tolerances as fine as 0.000005 of an inch.

YOU are on the ball, too, with Universal Precision Balls.

UNIVERSAL QUALITY CONTROL—FOR ALL AROUND PERFECTION

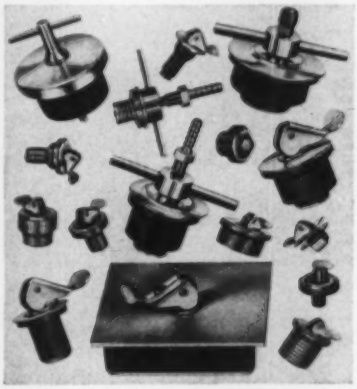
Universal Ball co.
WILLOW GROVE, MONTGOMERY CO., PA.

Circle 535 on page 19

New Parts

(*Continued from Page* 221)

machining potential rejects, and permanently replace threaded plugs and caps in finished products. Snap-Tite, for low pressure testing, adjusts to size with a twist of a cam lever, expands to seal opening irregularities when lever is depressed. Turn-Tite adjusts with the turn of a handle, seals more tightly against higher pressures with a further turn of the handle. Plugs are of stainless steel, brass, and zinc-plated cold-rolled steel. Seal is oil-resistant neoprene. They are available in round, square and special shapes. **Moeller Mfg. Co.,** 2405 Durand Ave., Racine, Wis.

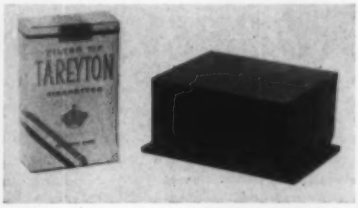


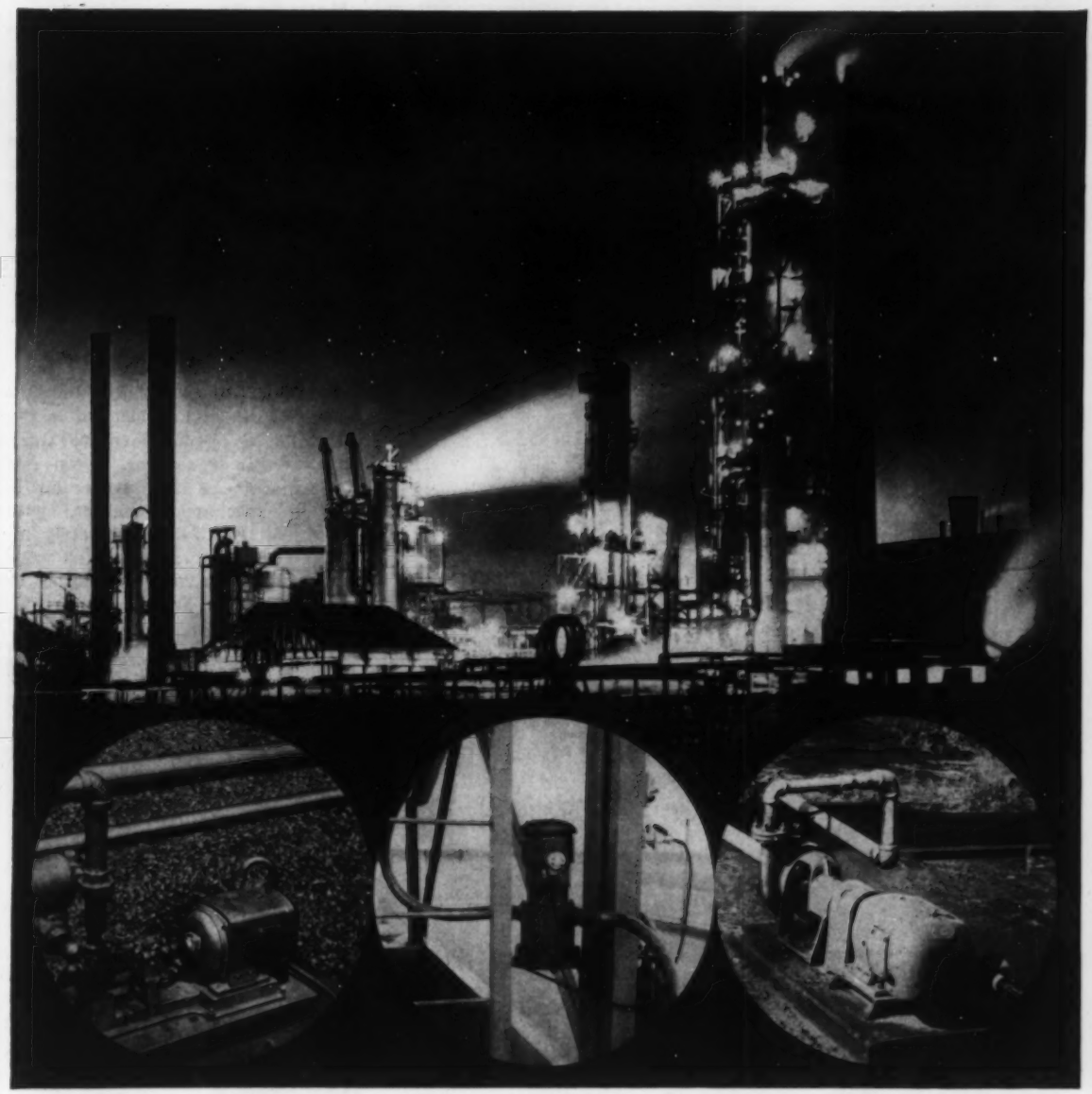
Circle 771 on page 19

Power Inverters

meet MIL-I-7032 and MIL-E-5272A specs

Transistorized power inverters consist of power transistors and other solid-state components. Unit shown is a 50-va, dc to ac inverter designed for gyro-motor excitation. Size is 2⅝ x 1⅞ x 3⅜ in. and weight is 15 oz. Input is 26 to 30 v dc, output, 115 v ac, 400 cps, square wave. Other inverters are available in ratings from 10 va to 2 kva, with square-wave, sine-wave single-phase or sine-wave three-





From the well to "Wabash and Main"...

LELAND EXPLOSION-PROOF MOTORS BRING YOUR FUEL

Oil and gasoline, butane and propane, and other hazardous liquids must be "pushed" into service! And the Petroleum Industry calls on Leland explosion-proof motors to do the pushing, safely and surely—from oil fields all the way to your car or door. Underwriters' Listed for Class 1, Group "D", naturally!

And Leland-powered pumps are "naturals" in *every phase* of this giant operation. They're at work in the oil fields, the refineries, at transfer and storage points, in giant fuel trucks, and even underground *in* gasoline tanks ... taking the worst the weather offers and the heaviest work loads...delivering the performance the job demands!

For over 30 years, Industry has looked to Leland for the finest in motors. With its complete explosion-proof line, including both integral and fractional, single phase and polyphase—plus its complete line of other standard motors, as well as a wide variety of specials—you'll find Leland is the answer to practically any motor need, from ¼ to 5 HP, soon through 10 HP. Why not investigate Leland? Write or call today.

Another AMF Product
LELAND MOTORS

THE LELAND ELECTRIC COMPANY
Dayton 1, Ohio
Division of AMERICAN MACHINE & FOUNDRY COMPANY

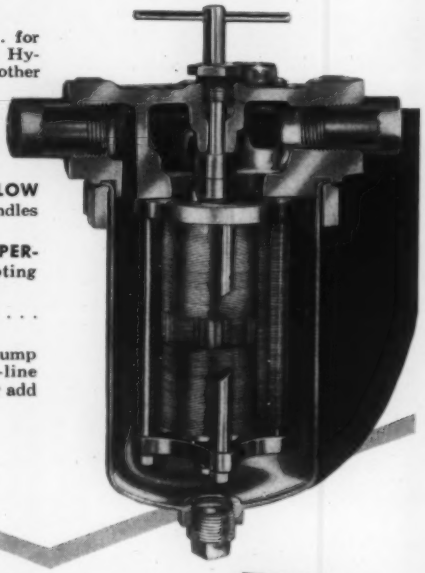
Circle 536 on page 19

FILTRATION *Engineered** TO MEET METAL WORKING NEEDS

CUNO

a Complete Line of Filters including AUTO-KLEAN and SUPER AUTO-KLEAN

- **POSITIVE PROTECTION** . . . for Coolant Systems, Lube Oils, Hydraulic Fluids, Chemicals and other Process Fluids
- **WIDE FILTRATION RANGE** . . . with spacings from .020" to .0015" (40 microns)
- **SMALL SIZE with HIGH FLOW RATE** . . . unit only 12" high handles over 50 gpm
- **SELF-CLEANING WHILE OPERATING** . . . without interrupting flow
- **ALL-METAL CONSTRUCTION** . . . carbon or stainless steel
- **AVAILABLE** . . . for direct-sump mounting or for separate in-line housing. Easy to build into, or add to, any machine or system.



* Only Cuno offers you a truly complete line that includes *several* distinct types of filter media. Cuno also offers you a complete application engineering service through a Cuno Field Engineer conveniently located in your area. He is qualified to help you select the right filter type and model to solve your problems.

WRITE NOW FOR FULLY DESCRIPTIVE PRODUCT LITERATURE . . . *Free Auto-Klean Bulletins will be sent to you by return mail.*

CUNO ENGINEERING CORPORATION
1406 SOUTH VINE STREET, MERIDEN, CONN.
TELEPHONE: BEverly 7-5541

EDGE-TYPE, WIRE-WOUND, SCREEN, FIBER CARTRIDGE and POROUS METAL FILTERS

Filtration Engineers in Principal Cities

New Parts

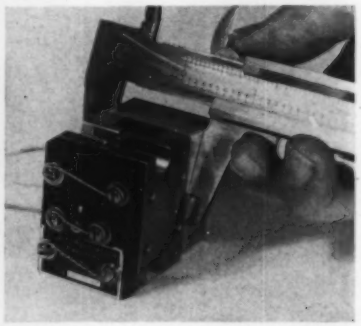
phase output rated at 115 v, 400 cps. Frequency and voltage regulation are held to ±1 per cent. Units meet requirements of specs MIL-I-7032 and MIL-E-5272A. **Modern Industries Inc.**, 2601 Colorado Ave., Santa Monica, Calif.

Circle 772 on page 19

Torque Motor

can be used in high humidities

Model 11 torque motor actuates the flow-controlling element in hydraulic or pneumatic servovalves. As a basic transducer, it converts a few watts of input power into a linear mechanical motion with forces up to 7.5 lb. Completely impregnated and incapsulated coils permit use in high humidities or



immersion in hydraulic fluids. Weighing 14 oz, unit operates at ambient temperatures to 300 F with frequency responses to 300 cps. **Midwestern Instruments,** Tulsa, Okla.

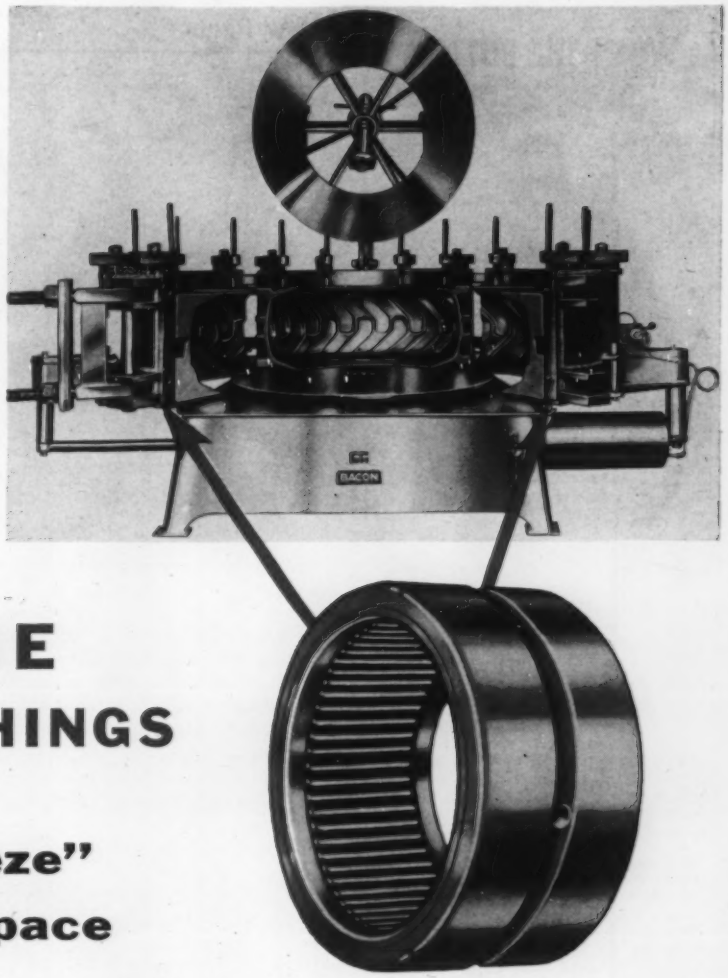
Circle 773 on page 19

Hydraulic Cylinder

is self-locking

Rhucor self-locking hydraulic cylinder combines linear actuation and mechanical locking in a single unit. Envelope dimensions and weights are approximately the same as standard aircraft cylinders. Unit meets all applicable military specifications. Integral lock is operated by hydraulic pressures up to 4500 psi. It can lock and unlock at any desired pressure and any load in extended or retracted position. Cylinder has steel barrel and piston with aluminum end. It is available in any required

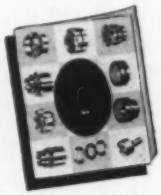
Bacon All-Purpose Tire Molds feature an exclusive "squeeze" principle through air-actuated mechanisms, which provide perfect treads without distortion on all sizes of tires from motorcycle to largest 18:00-24 truck tires. All hinges are mounted on Orange Roller Bushings to eliminate friction and assure smooth operation while opening and closing.



ORANGE ROLLER BUSHINGS meet a "Tight Squeeze" in Load and Space

Orange Roller Bushings are available in stock sizes from ½" to 8" shaft dia., fully interchangeable with all standard heavy-duty needle bearings. Stocks and engineering service in all principal industrial areas.

WRITE for free 40-page Engineering Reference Manual M-56 giving details of construction, dimensions, capacities, etc., on complete line of Orange Roller Bearings.



In addition to meeting load requirements, engineers at Bacon Vulcanizer Manufacturing Company put a "tight squeeze" on space requirements due to the high-load, small-space advantages of Orange Roller Bushings.

Orange Roller Bushings are full-type needle bearings built for heavy-duty service. Rollers and races are made of finest bearing steel—hardened, ground and finished to highest precision standards. Roller uniformity is controlled by electronic gauging, permits closer internal running clearances, minimizes possibility of misaligned rollers.

Wherever a shaft or part rotates or oscillates, Orange Roller Bushings offer great opportunity to fight friction and wear, save space, eliminate trouble spots and improve performance.

ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

WHEN THE BOTTOM DROPPED OUT of the ERIE CANAL

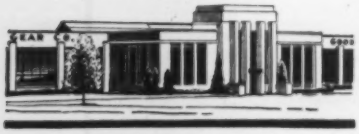
Of the many noteworthy events that took place back in 1907, one of the most unusual occurred near Syracuse New York, where a part of the bottom of the Erie Canal dropped out. Four canal boats were sucked through and shattered; a flour mill was badly damaged; and there was a loss of over $500,000. This catastrophe may sound more believable when we tell you that the break occurred on a viaduct over Onondaga Creek.

In a more constructive vein, a happier (if less publicized) event occurred in Cincinnati in the same year, when Soren Sorensen and John Christensen founded what was to become The Cincinnati Gear Company.

In the ensuing fifty years, many changes have taken place. People no longer ride on canal boats; and the gear-manufacturing business has progressed similarly. Technologically we've been in the forefront of this progress, but we've also tried to preserve some of the attention to detail and "craftsmanship" that prevailed in those earlier times. The result has been a gratifying record of customer satisfaction — the kind of satisfaction we'd like *you* to experience on your next custom gear order.

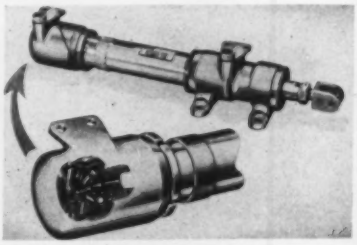
THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
Fifty Years of "Gears—Good Gears Only"

CINTI®



Circle 539 on page 19

New Parts



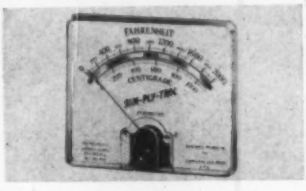
bores and strokes. **Ronson Hydraulic Units Corp.**, 1313 Lincoln Ave., Pasadena 3, Calif.

Circle 774 on page 19

Indicating Pyrometers

in 21 standard ranges

Indicating pyrometers, redesigned with mirror scales to cut down parallax effect, can be read accurately from all angles. Of medium-resistance type, they are available in 21 standard ranges from −400 to 100 F, to zero to 3000 F. Full scale accuracy of 2 per cent is standard. Units can be thermistor-compensated to maintain accuracy in spite of ambient temperature changes, and are furnished with compensation for changes in cold



junction. Panel-mounting types, portable units and bench models are available. **Assembly Products Inc.**, Wilson Mills Rd., Chesterland, O.

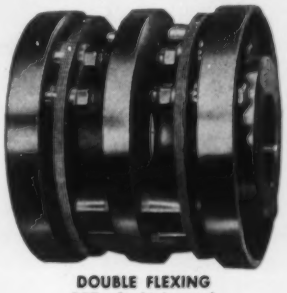
Circle 775 on page 19

Shredded Metal Packings

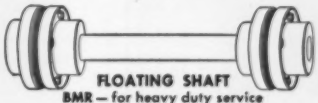
for high-temperature use are of copper tinsel

Styles 934 and 935 shredded metal packings are for use under very high steam pressures and temperatures to 1500 F. They are recommended for use with steam, air, water or gases (except ammonia) on valve stems, reciprocating rods, and rotary shafts of pumps, blowers, turbines, compressors and similar equipment. Both styles are copper tinsel, treated with rubber

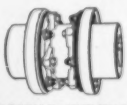
FOR MAINTENANCE FREE POWER TRANSMISSION
Specify
THOMAS
FLEXIBLE COUPLINGS



DOUBLE FLEXING
DBZ — for high speed, heavy duty drives



FLOATING SHAFT
BMR — for heavy duty service with excessive misalignment



DOUBLE FLEXING
AMR — for engine and medium speed drives

SINGLE FLEXING
SS — for engine-driven generator sets with out-board bearings

Thomas' 40 years of flexible coupling experience is at your disposal to help you meet ordinary applications or special variations for unusual cases.

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES.

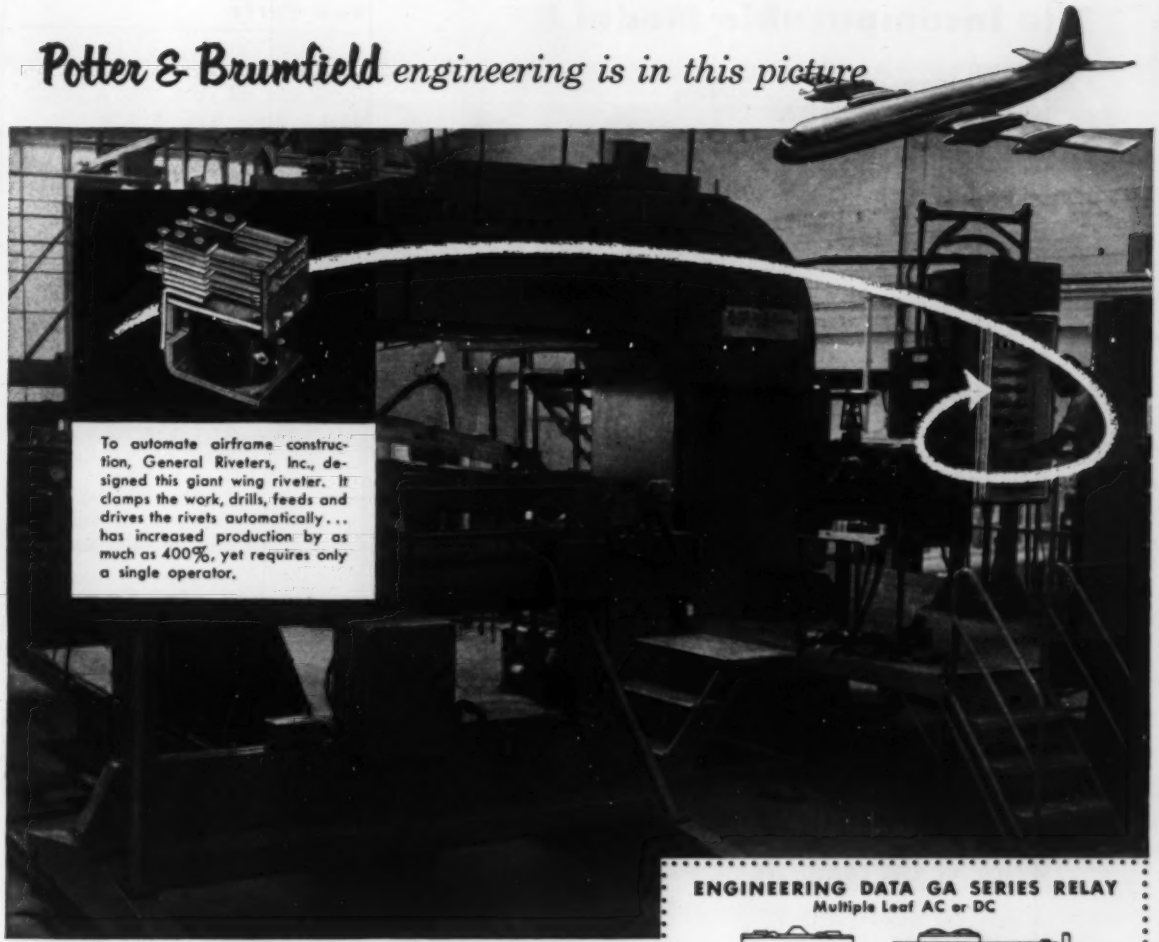
1 Freedom from Backlash Torsional Rigidity
2 Free End Float
3 Smooth Continuous Drive with Constant Rotational Velocity
4 Visual Inspection While in Operation
5 Original Balance for Life
6 No Lubrication
7 No Wearing Parts
8 No Maintenance

Write for Engineering Catalog 51-A

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U. S. A.

Circle 540 on page 19

Potter & Brumfield *engineering is in this picture*



To automate airframe construction, General Riveters, Inc., designed this giant wing riveter. It clamps the work, drills, feeds and drives the rivets automatically... has increased production by as much as 400%, yet requires only a single operator.

P&B RELAYS AUTOMATE THIS GIANT RIVETER *for new Lockheed Electra Wings*

This new automatic riveter will be used to make wings for the new Lockheed Electra, a prop-jet luxury liner, as well as many other modern aircraft. The heart of this riveter is a relay circuit that "takes orders" from a pattern of holes punched in 35 mm film strips.

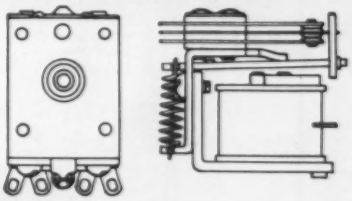
General Riveters, Inc. selected the GA Series P&B relay for the control circuits of this riveter because of its unusual dependability and versatility. In adapting this relay to a specific application, P&B's engineers again demonstrated how 25 years of creative engineering can pay off by providing a standard type or completely new relay to solve your particular problem. Write today for new compact catalog or engineering consultation.

P&B Standard Relays are available at your local electronic, electrical and refrigeration distributors

Potter & Brumfield, inc.

PRINCETON, INDIANA *Subsidiary of* AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

ENGINEERING DATA GA SERIES RELAY
Multiple Leaf AC or DC



CONTACTS
Material: ⅜" fine silver (other contact materials can be furnished for specific applications)
Rating: 5 amp. 115 V. 60c non-inductive load
Arrangements: 4 Form C Max., AC; 6 Form C Max., DC
Breakdown: 1000 V. RMS between all elements

COIL
Resistance: 30,000 ohms max.
Power req'd: 6 W. max., 2 W. min. DC at 25° C. ambient
V range: DC to 110 V.; AC to 230 V.

DIMENSIONS, MAX.
$1^{23}/_{32}$" L. x $1^{1}/_{16}$" W. x $1^{23}/_{32}$" H.

MOUNTING DATA
4 tapped #6-32 holes, .750" x .875" o.c. 1 tapped #8-32 core

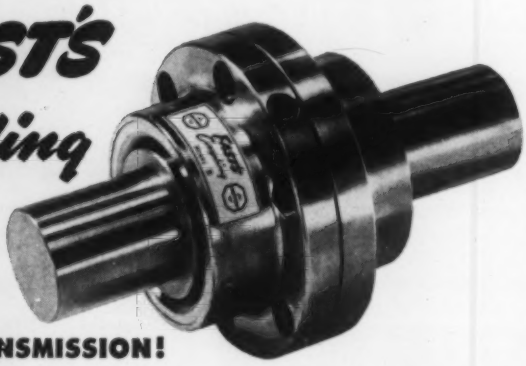
ENCLOSURES
Hermetically sealed, octal plug: $2^{17}/_{32}$" x $1^{29}/_{32}$" x $1^{23}/_{32}$"
Multiple solder header and miniature plug-in: $2^{13}/_{32}$" x $1^{29}/_{32}$" x $1^{23}/_{32}$"
Special container required for 6 Form C

TERMINALS
Contacts: two #16 AWG wires
Coil: two #20 AWG wires

See our catalog in Sweet's Product Design File

The incomparable Model B

FAST'S Coupling



LOW-COST POWER TRANSMISSION!

Designed for light and medium drives—fans, blowers, pumps—a lighter, smaller and lower priced Fast's Coupling! The same famous features found in all Fast's Couplings . . . the same mechanical flexibility, the same positive lubricating principle, the same rugged construction and trouble-free performance . . . the same highly efficient power transmission which has made Fast's Couplings the leader for more than 30 years! Available for shaft sizes up to 2⅝" and sold with Koppers' free engineering service. For the low-cost solution to your shaft coupling problem, write: Koppers Company, Inc., *Fast's Coupling Dept.*, 3506 Scott Street, Baltimore 3, Md.

THE ORIGINAL

KOPPERS **FAST'S Couplings**

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus. *Engineered* Products Sold with *Service*.

Circle 542 on page 19

Write for the complete new ENGINEERING BULLETINS—

PHILLIPS RELAYS

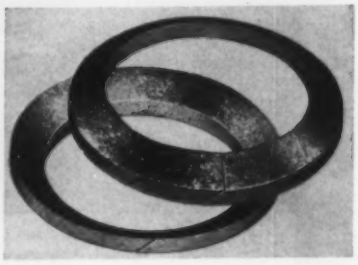
IN PERMANENT BINDER

Ready for your reference files now —latest set of Phillips Relay engineering bulletins in durable ring binder. Easy-to-read, comprehensive folders provide relay characteristics, features, dimensional drawings and stock listings. Additional folders will be sent you as available. Start your own relay file today.

PHILLIPS CONTROL CORPORATION • 59 W. Washington St., Joliet 2, Ill.

New Parts

cements, graphited, molded to shape and cut open with a beveled joint. Style 934 is available in ring form only; Style 935 (shown) is a packing set consisting of conical-shaped molded-center rings



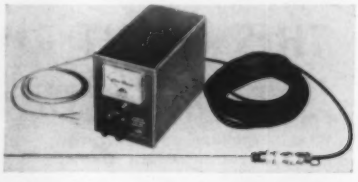
with 120-deg included angle and bronze top and bottom adapters. **Garlock Packing Co.**, 407 Main St., Palmyra, N. Y.

Circle 776 on page 19

Hot-Wire Anemometer

measures high-speed flow phenomena

Constant temperature hot-wire anemometer measures high-speed flow phenomena. Constant-temperature operation provides maximum sensitivity with minimum wire burnout. Operation is automatic in that no time-constant testing or gain settings are required, affording self-regulation over a



wide range of flow. It has frequency response of dc to 1000 cps and noise level of less than 1 per cent of mean flow level. **Aero Research Instrument Co.**, 315 N. Aberdeen St., Chicago 7, Ill.

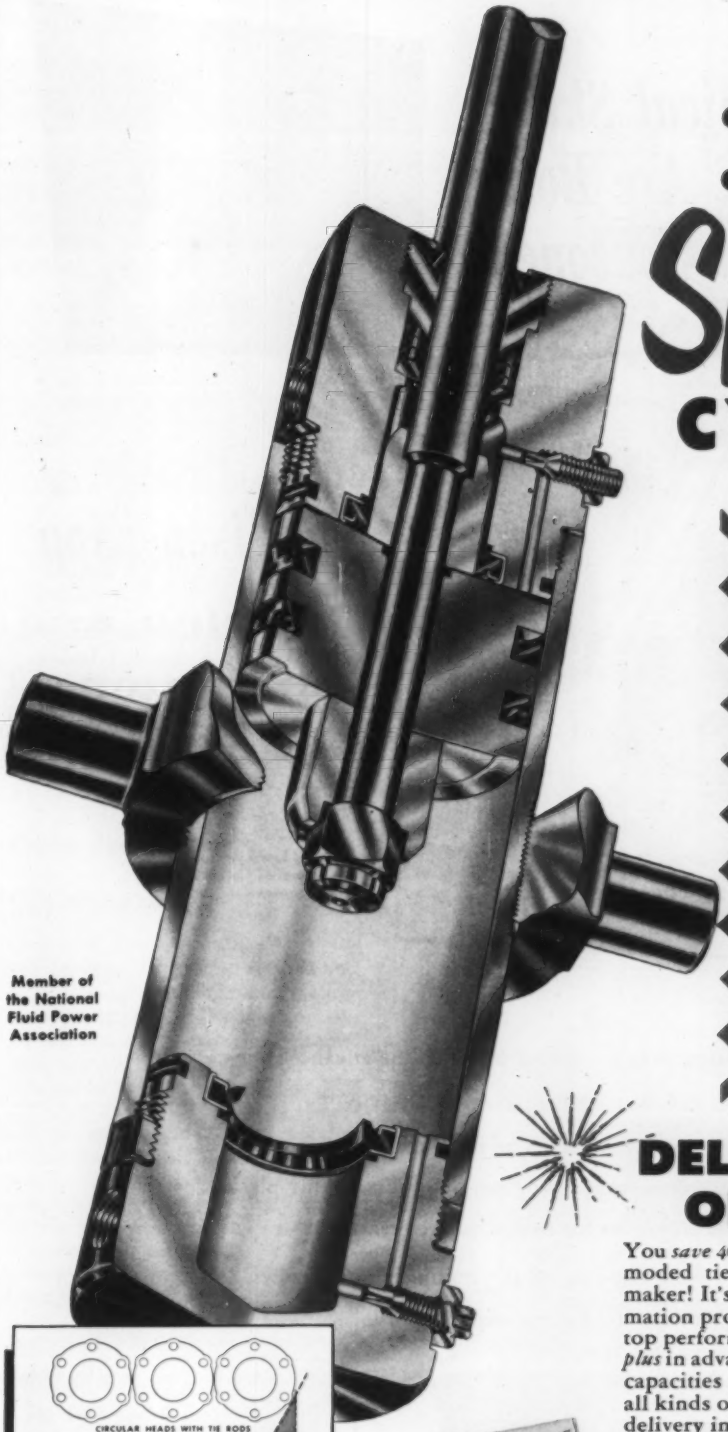
Circle 777 on page 19

Shut-Off Valves

for cryogenic media

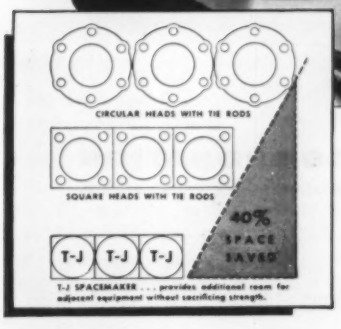
Motor-operated shut-off valves for airborne and ground use are for applications that require bubble-tight flow control of material to −320 F and pressures to 3000 psi. Typical gases and liquids handled

all the EXTRAS are standard with T-J Spacemaker CYLINDERS



Member of the National Fluid Power Association

- **NEW** *exclusive* ingenious cushion designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Cushion for Oil.
- **STRONGER** than outmoded tie rod design, proven through actual tests. No tie rods to stretch.
- **SOLID STEEL HEADS** throughout the full line.
- **COMPACT DESIGN** eliminates tie rods, increasing the strength and reducing mounting space required, providing extra room for adjacent equipment.
- **HARD CHROME PLATED** body bores and piston rods . . . assure you of long trouble-free service. (Standard at no extra cost.)
- **METALLIC ROD SCRAPER,** not just a wiper, actually removes foreign matter from the rod.
- **PILOTED PACKING GLAND** with extra long bearing. Additional strength and support to the piston rod.
- **OIL** pressure to 750 p.s.i. AIR to 200 p.s.i.


CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
T-J
T-J
T-J
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

DELIVERY OFF THE SHELF!

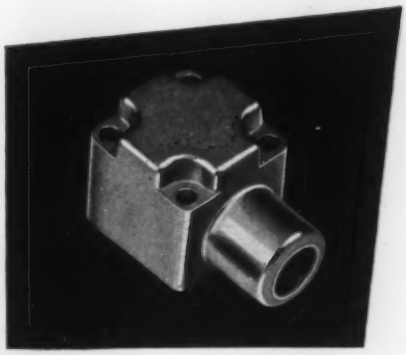
You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift operations. Off-shelf delivery in 64,000 combinations!

NEW LITERATURE—Send today for new Catalog SM56 with complete engineering details on Spacemaker line. Write The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHERS

Circle 544 on page 19

The Rare Mechanical Skills Required Are Both Predominant and Seasoned



One of the Add-Ons for the main switch housing

at Madison-Kipp

for zinc and aluminum die castings

Unusual switch parts—requiring seasoned mechanical skills for full process utilization.

Full process utilization is the telling factor in the advanced die casting process. Outstanding and rare mechanical skills are required for best results.

Such skills at Madison-Kipp, from preliminary blue print analysis through die designing, die making and die casting have been helpful to highly placed product designers and engineers for over a quarter century.

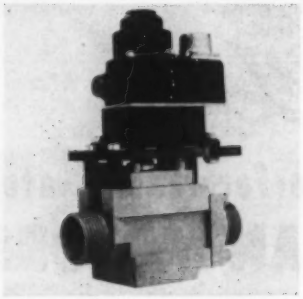
Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

include oxygen, nitrogen, air, helium, liquid oxygen, liquid nitrogen and liquid air. Floating ball-seat valve arrangement with self-wiping and self-lapping action insures long life. Operating times from 0.5 to 5.0 seconds are available. Valves have aluminum body,



aluminum and hard-chromed stainless-steel internal parts, and Mylar, Kel-F and Teflon seals. Complete range of line sizes is available, from ¼ to 1½ in. **Hydromatics Inc.**, Cedar Grove, N. J.

Circle 778 on page 19

Rubber-Base Adhesive

requires no overlap of joint

Ray-Bond R-87001 rubber-base adhesive, used for joining fabrics and other porous materials, has instantaneous grab. Adhesive permits joining ends of material without overlapping. Tensile strength is 104 psi after 10 minutes and 112 psi after 24 hr. Material is resistant to water and diluted alkalis. It can be applied by extrusion or brush. Joined parts can be used immediately after pressing together, but highest strength is obtained if allowed to set for 24 hr. **Raybestos-Manhattan Inc.**, Adhesives Dept., Bridgeport 2, Conn.

Circle 779 on page 19

Gearmotors

for slow-speed power applications

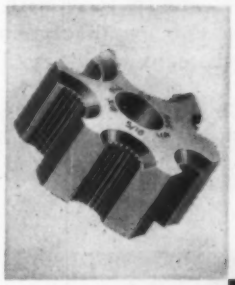
Redesigned gearmotors are available with polyphase, single-phase and dc motors, with variety of mounting positions possible, including downshaft and tilted shaft. They can be obtained in open dripproof, dustproof, explosionproof,

GIVING YOU

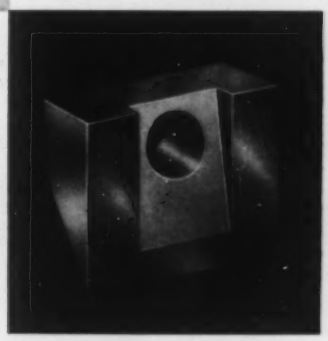
...the best and most modern!

Bunting today covers a new area in the engineering and manufacture of bearings and machine parts. To the traditional line of Bunting Cast Bronze Bearings and parts is added up-to-date, soundly established facilities for engineering and manufacturing bearings and parts made of Sintered Powdered Metals.

In an entirely new plant with the very latest equipment, Bunting now attains the position in the Sintered Powdered Metals field which it has long held in the field of Cast Bronze Bearings.



A competent group of Bunting Sales Engineers in the field and a fully staffed Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.



Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

Bunting®

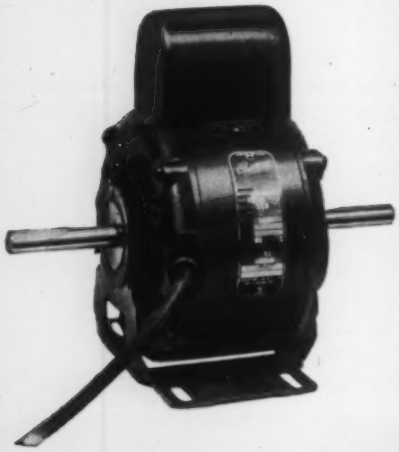
BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 546 on page 19

More POWER with Less Amps!

Century Performance-Rated® FAN MOTORS



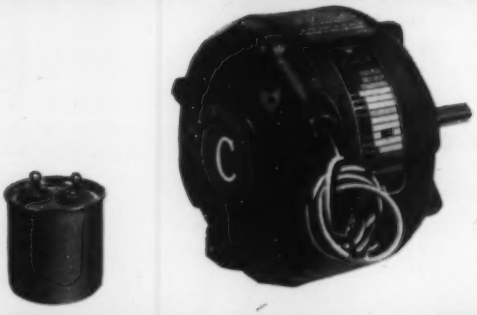
HELP SOLVE YOUR LOAD AND POWER FACTOR PROBLEMS

In air conditioning or ventilating equipment, you can reduce starting current, reduce running current and increase power factor with these new Century Fan Motors. They are Performance-Rated for air conditioning manufacturers who are faced with new load and power factor problems. Fan manufacturers find advantages in their short length, light weight, multi-speeds and easy reversibility.

In your product and in your plant, Century Motors are Performance-Rated to fit your needs. For information, call your nearby Century Sales Office, or write us direct.

Type C, Permanent Split Capacitor . . . round frame, single speed, reversible—also available with cushion mounting.

Type CM, Permanent Split Capacitor . . . round frame, 2 or 3 speeds, all reversible—also available with cushion mounting.



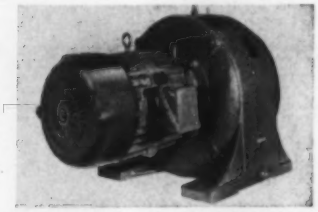
CE-75

Performance-Rated®
1/8 to 400 H. P.

CENTURY ELECTRIC COMPANY

1806 Pine St., St. Louis 3, Mo. • *Offices and Stock Points in Principal Cities*

Circle 547 on page 19



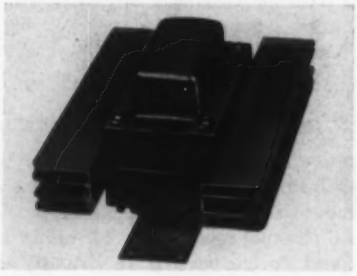
and totally enclosed frames. Motors are for slow-speed power applications. Unit shown is available in single, double and triple reduction with output speeds from 750 to 7.5 rpm. **Century Electric Co.**, 1806 Pine St., St. Louis 3, Mo.

Circle 780 on page 19

Power Transformer

has multiple-fin construction

Fin-cooled power transformer for television receivers uses multiple-fin construction to increase surface area which dispels heat developed by the unit. This steps up rate of heat dispersal, permits a reduction in the amount of iron and copper used, and reduces weight of transformer. Unit pulls cool air in from



a vent on the under side of chassis. Air rises through vertical fins, cools transformer, and escapes at top of cabinet back. **Zenith Radio Corp.**, 6001 W. Dickens Ave., Chicago 39, Ill.

Circle 781 on page 19

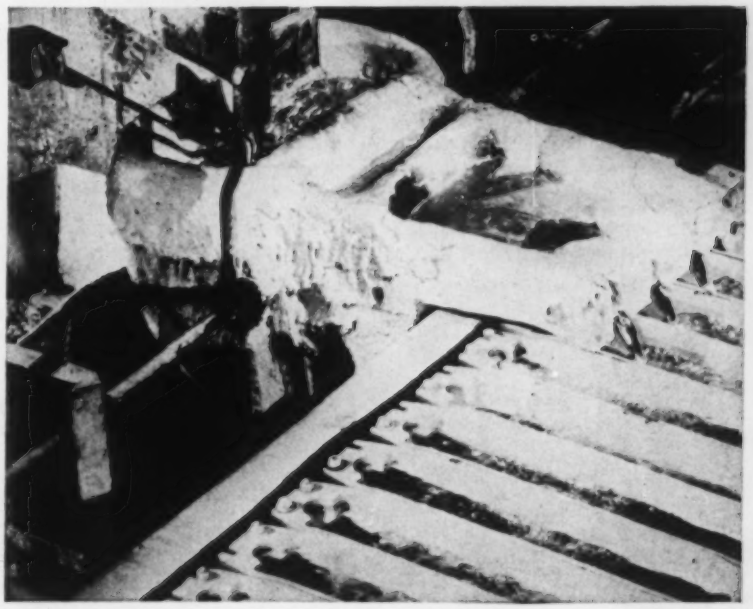
Variable-Displacement Pump

for controlled-flow applications

Pump is equipped with speed-control valve which handles, at wide-open positions, maximum capacity of pump. Output from full flow to zero can be obtained over a 90-deg movement. Standard speed-

(*Continued on Page* 238)

Federated Aluminum Alloys always conform to published Performance Specifications



If you have had reason to doubt the performance capacity of certain aluminum alloys, it will pay you to consult Federated before you re-design or substitute another metal.

Often the performance requirements of a part indicate that a certain aluminum alloy will do the job; yet in operation, the part fails. Costly re-design or a more expensive metal are usually relied upon to rectify the trouble.

All aluminum alloys should provide the characteristics set for them in published specifications. At Federated's three aluminum plants, rigid quality control insures that production ingot adheres exactly to specified content. Impurities are held at or below the minimum allowable percentage.

Every heat of every Federated aluminum alloy is tested exhaustively. Refining, alloying and testing techniques are under strict quality-control procedures, developed by ASARCO's Central Research Laboratory, where scientists can control metal impurities to parts per million, if required.

A Federated field man will be around to see you soon. Spend some time with him. It will benefit you.

Federated Metals

ASARCO

Division of

AMERICAN SMELTING AND REFINING COMPANY

120 Broadway • New York 5, N.Y.

In Canada: Federated Metals Canada, Ltd., Toronto and Montreal

Circle 548 on page 19

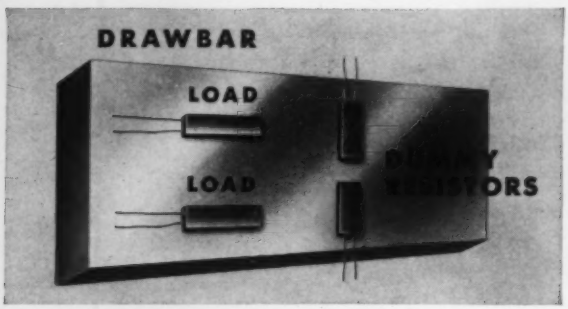
SAVE ENGINEERING TIME WITH DIRECTLY RECORDED PHYSICAL MEASUREMENTS

Brush oscillographic systems simplify analysis of stress, strain, torque, other variables.

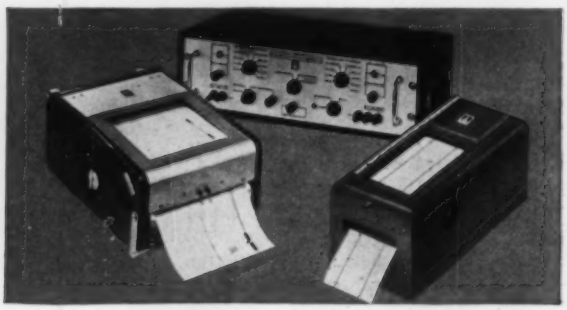
THE USE of Brush direct-writing oscillographs is now simplifying many new measurement problems where physical deformation occurs.

By cementing a strain gage wire to the surface to be tested, resistance will vary with any dimensional change, a proportionate change in resistance.

Output of the pickup element is fed into a Brush amplifier, then to a direct-writing Oscillograph. This provides you with an instantaneous, visible, reproducible, permanent record. Brush oscillographs offer a wide range of



Location of gages for measuring torque



Brush portable oscillographs and amplifiers

and changes can be directly recorded on an oscillograph. ***Such recording is instantaneous and manual plotting of data is eliminated.*** New Brush oscillographs and related amplifiers provide excellent readability in recording a wide range of strain gage measurements.

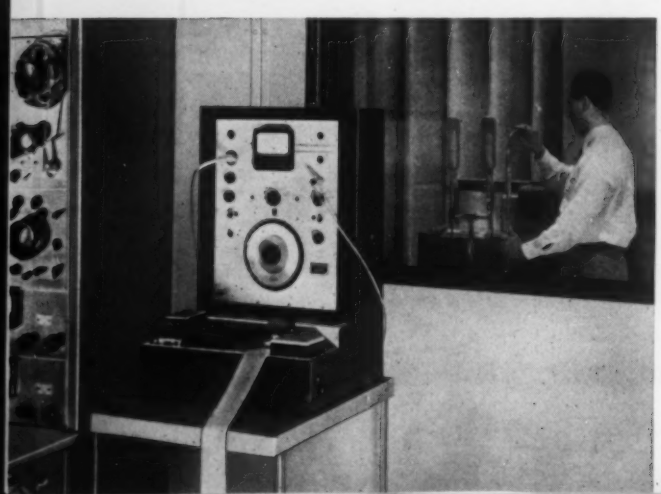
INSTRUMENTATION REQUIRED

Gages incorporating the sensing wire can be obtained with paper or plastic as a base material. Likewise, transducers which incorporate gages are available. These transducers convert physical phenomena such as pressure, force, displacement, acceleration, torque, or load to

chart recording speeds — from 10 inches per day to 10 inches per second. Variables from d.c. to 100 cycles per second can be recorded.

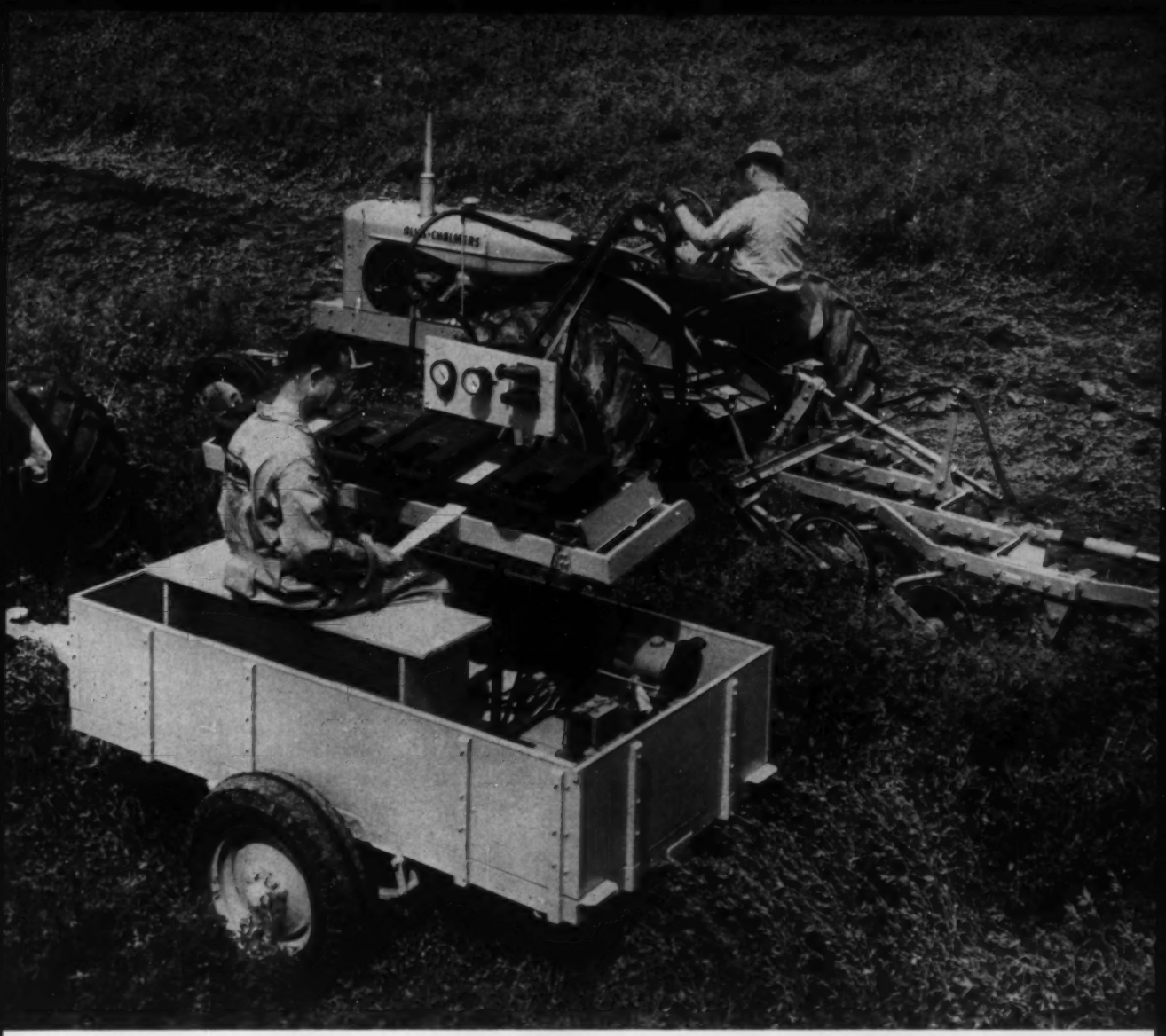
SELECTION OF RECORDING EQUIPMENT

A Brush representative can help you select the proper recording equipment from Brush's complete line... covering portable, rack-mounting, or bench-top console equipment... for 2, 4, or 6 channel recording... for either ink or combination ink and electric writing. In virtually any kind of measurement, ***you'll get the facts easier and faster with Brush equipment.***



IBM NOISE REDUCTION PROGRAM EXPEDITED WITH BRUSH INSTRUMENTATION

This section of the International Business Machines Corporation's Testing Laboratory gets facts on noise to make office machines quieter. A Brush-Bruel & Kjaer Spectrum Recorder analyzes and records all sounds from 14 cycles to 36,000 cycles per second, in one-third octave steps. Unit operates automatically, presents data in a form most useful for noise reduction. Described in booklet "Sound Measurements."



ALLIS-CHALMERS FIELD MEASUREMENTS ANALYZE TRACTOR PERFORMANCE

This mobile test setup furnishes data on weight variation, hydraulic system pressure variation, rear axle torque, drawbar load, time and distance traveled, rear wheel revolutions, engine speed, manifold depression—to provide useful performance data.

Instrumentation includes four Brush Analyzers, two Brush Oscillographs, and strain gages, used as follows:

Weight variation on front end: 4 strain gages positioned on a cantilever beam support to cancel everything but bending movement. Data recorded on Brush Oscillograph.

Pressure variation in hydraulic system: Pressure transducer measures pressure variations to check additional weight as it is transferred to tractor rear wheels. Data recorded on Brush Oscillograph.

Rear axle torque: Strain gage mounted rear axle, leads brought out through mercury chamber pickup and data recorded on Brush Oscillograph.

Drawbar load: Strain gage bridge mounted on plow hitch. Data recorded on Brush Oscillograph.

Time and distance, etc.: A fifth wheel on the implement serves as a measure of distance and determining percent of slippage. A contacting device on the fifth wheel energizes event markers on the oscillograph charts. Other variables measured by tachometers and gages.

Write Dept. R-6 for new booklet "Strain Recording"

BRUSH ELECTRONICS COMPANY

3405 Perkins Avenue, Cleveland 14, Ohio

BRUSH ELECTRONICS

DIVISION OF CLEVITE CORPORATION

OSCILLOGRAPHIC RECORDING SYSTEMS • SOUND INSTRUMENTATION • MAGNETIC COMPONENTS • PIEZOELECTRIC MATERIALS • WEAPONS SYSTEMS

Circle 549 on page 19

One Source for ALL Work-Holding Needs

• • •

TOGGLE CLAMPS

80 TYPES and SIZES

Featuring REAMED HOLES, for better bearing — HARDENED BUSHINGS—SERRATED to prevent turning — HIGH TENSILE STRENGTH RIVETS for longer service.

WESPO

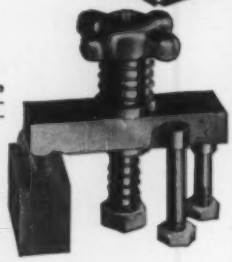
NEW — TOGGLE PLIERS

Movement of Trigger in either direction, releases pressure on Plier.

FIXTURE CLAMPS

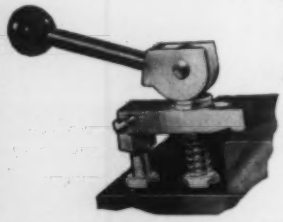
16 STYLES—170 SIZES

WESPO fixture clamp assemblies save up to 70 percent on your own designing and machining. They are standard with leading manufacturers.



NEW — SWINGLOCK CLAMP

Fastest Hand Operated Clamp Available.



COMPONENTS

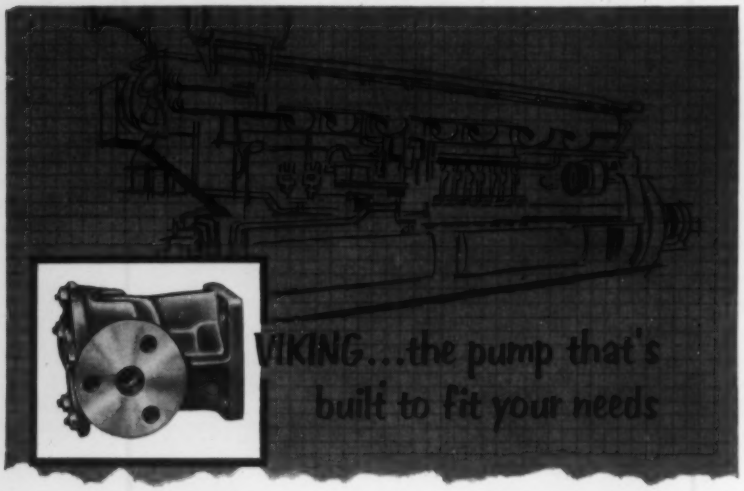
1000 TYPES AND SIZES

Write for Catalogs

WEST POINT MFG. CO

26941 W. 7 Mile Road • Detroit 19, Michigan

Circle 550 on page 19



Whatever your needs in a pump . . . whether it's bearing lubrication, coolant or fuel delivery . . . there is a Viking Pump in the size you need—2/3 to 1050 GPM.

If you want a pump to fit your equipment, Viking will furnish the right pump. More than 750 catalogued models are available, PLUS special units. If you need special pumps, take advantage of Viking "know-how", based on experience in designing thousands of special pump installations.

For more information, write for Catalog 57Sh today.

VIKING PUMP COMPANY

Cedar Falls, Iowa, U.S.A. In Canada, it's "*ROTO-KING*" pumps

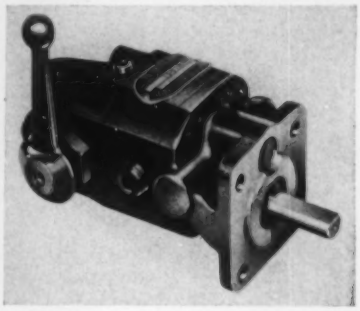
See our Catalog in Sweet's Product Design File

Circle 551 on page 19

New Parts

(*Continued from Page 235*)

control handle is provided. Pump is available in flow ranges of 0 to 1, 0 to 2, 0 to 4 and 0 to 6 gpm. Applications include controlled flow for traversing table of a small



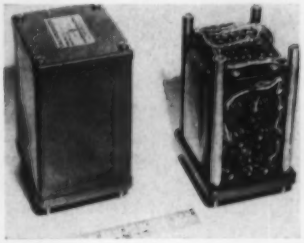
grinder, controlled flow for lubricating systems, and controlled flow for reciprocating-type cylinders. **John S. Barnes Corp.**, 301 S. Water St., Rockford, Ill.

Circle 782 on page 19

Power Converters

for 12 and 28-v inputs

Lightweight dc to dc power converters for portable, aircraft and vehicular electronic equipment are tubeless, transistorized units. They are available for 12 and 28-v inputs, in nominal output voltages from 120 to 2100 and in power outputs to 500 w. Units can be made to meet military specifications. Standard op-



erating temperature range is −40 to 71 C. **Universal Transistor Products Corp.**, UAC Electronics Div., 143 E. 49th St., New York 17, N. Y.

Circle 783 on page 19

Shaft Adapters

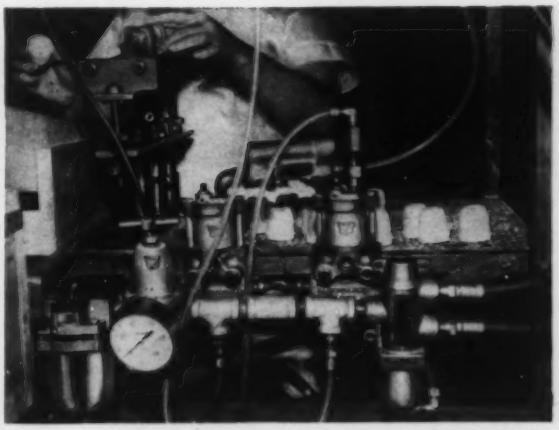
for miniature motor drives

BF-type motor-shaft adapters and taper motor-shaft converters con-

***Progress** in designing air systems:*

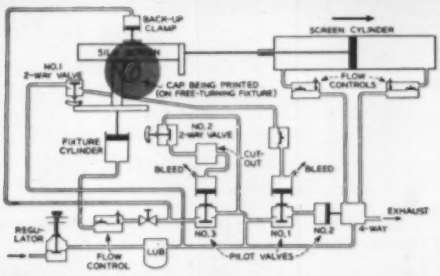
Here's an automating idea: Schrader Air Products in a precision programming operation

PROBLEM: To print bottle caps accurately at high speed.

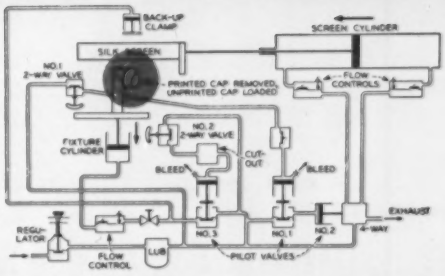


PROVED IN OPERATION: Prominent silk screen printer puts Schrader products to work at a profit.

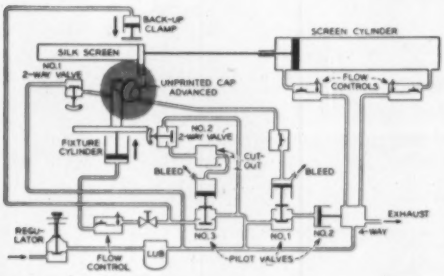
SOLUTION: Adapt Schrader Air Products to silk screen printer.



Fixture holding plastic cap on freely rotating fixture is held up against silk screen by Schrader cylinder. Another Schrader cylinder pushes screen sideways over the freely rotating cap, imparting the printed message.



Fixture with printed cap moves down, back-up clamp retracts and screen cylinder returns to initial position. Operator removes printed cap and loads another unimprinted cap.



Schrader cylinder advances fixture upward loaded with unimprinted plastic cap. Back-up clamp starts downward toward silk screen. And cycle starts all over again.

This is but one precision operation of the limitless operations which can be controlled *fast, economically* and *accurately* by Schrader Air Products. The hundreds of different units in Schrader's complete line can be employed alone or in combination to perform stamping, programming, forming, measuring, squeezing—other jobs too! And wherever air is used, economy is basic.

Test the performance of all your machines against the efficiency that could be achieved with air. Schrader engineering facilities are available to help you. Outline your problem to us and assistance will be prompt. Right now, mail the coupon.

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QUALITY AIR PRODUCTS

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476 Vanderbilt Avenue, Brooklyn 38, N. Y.
Please send latest informative booklets which show Schrader's complete line of Air Control Products.

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Company_____

Address_____

Circle 552 on page 19

"FAIRFIELD for FINE GEARS"

WHAT **FAIRFIELD**
Facilities CAN MEAN TO YOU

1. **MASS PRODUCTION ECONOMY**—Large or small, you get the benefits of high production rates and big volume output at Fairfield—where fine gears are produced to meet your specifications EFFICIENTLY, ECONOMICALLY!
2. **QUALITY PLUS**—There is no finer recommendation for the quality of the product you sell than to be able to say it is "EQUIPPED WITH FAIRFIELD GEARS!"
3. **DEPENDABLE SOURCE OF SUPPLY**—Fairfield is one of America's largest independent producers of precision-made, automotive type gears for leading builders of construction, agricultural, industrial, marine, and automotive equipment.
4. **BACKED BY EXPERIENCE**—Unexcelled facilities in an ultramodern plant backed by more than thirty-five years' experience in producing Spur, Herringbone, Spiral Bevel, Straight Bevel, Hypoid, Zerol, Worms and Worm Gears, Splined Shafts, and Differentials to customer's specifications.
5. **ENGINEERING SERVICE**—Fairfield engineers are qualified to make expert recommendations on your gear production requirements. *Your inquiry will receive prompt attention.*

FAIRFIELD
MANUFACTURING CO.

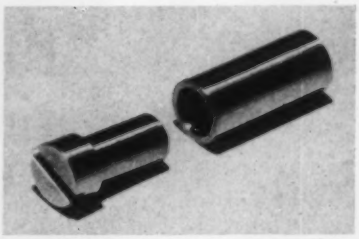
2307
S. Concord Rd.

for FINE GEARS

Lafayette,
Indiana

Circle 553 on page 19

New Parts



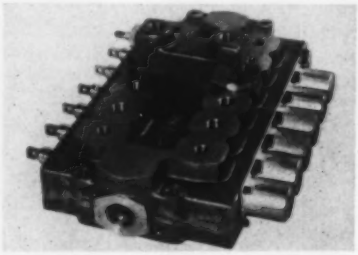
vert most Diehl-type rotating-component shafts to standard ¼-in. straight shafts. Material is No. 303 stainless steel, clear passivated. Outside diameter is 0.250-in.; length of adapter, less screw, varies from 9/16 to 41/64-in. BF-4 model conforms to BuOrd drawing No. 1039667. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, N.Y.

Circle 784 on page 19

Control Valve

controls double or single-acting cylinders

Hydreco parallel - circuit control valve has a capacity of 35 gpm at 2000 psi. Six plungers control double or single-acting cylinders. Valve is used for multiple operation of cylinders in parallel where rapid operations are required. Check valves are incorporated into



each plunger to prevent back flow from cylinders when operating positions are changed. **New York Air Brake Co.**, Kalamazoo Div., Kalamazoo, Mich.

Circle 785 on page 19

Time Switch

controls intermittently operated equipment

Completely automatic control of intermittently operated equipment is provided by a new 24-hr time switch. It handles up to 48 "on"

Carpenter... pioneering in improved Tool, Alloy and Stainless Steels through continuing research

TEMPERATURE: 110° F.
Permanent magnet assembly for watthour meter employing a magnetic shunt of Carpenter Temperature Compensator "30."
TEMPERATURE: -15° F.

When Precision Equipment Must Behave at Varying Temperatures...

Take Advantage of *Carpenter* High Nickel Alloys!

A specially-engineered steel in Carpenter's complete line of high nickel alloys is guarding the accuracy of watthour meter performance in all kinds of weather. Its use covers a wide range of electrical equipment such as watthour meters, voltage regulators, speedometers and aircraft tachometers.

This alloy, Carpenter Temperature Compensator "30", is produced by specialists under strict quality controls. It is another example of how Carpenter's pioneering role in producing *specialty* steels to meet *special* applications works for you in your effort to build better products at a reasonable cost.

And Temperature Compensator "30" is but one of many Carpenter specialties. Other "extremely sensitive" alloys in this line respond to very weak electrical currents . . . permitting you to design smaller, lighter weight units. Still another Carpenter High Nickel Alloy assures precision product performance with practically no size change through temperature ranges up to 400°F.

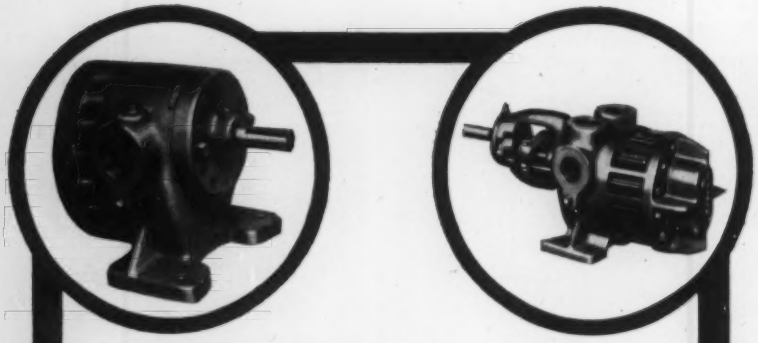
Take this step for product improvement, now: Write on your company letterhead for detailed information on Carpenter Temperature Compensator, Low Expansion, High Permeability and Glass Sealing Alloys in such forms as strip, wire, bars, tubing and forging billets.

Carpenter STEEL

high nickel alloys

The Carpenter Steel Co., 120 W. Bern St., Reading, Pa.

Export Department: The Carpenter Steel Company, Port Washington, N. Y.—"CARSTEELCO"



WHAT ARE YOUR REQUIREMENTS IN A ROTARY PUMP?

Today perhaps your requirements are for *hydraulic applications* . . . next week for *processing equipment* . . . next month for *pressure lubrication* on industrial equipment. Whatever the need, Roper has the *right pump* for you—to do the job better!

ROPER DESIGNS AND BUILDS CUSTOM PUMPS

Roper's basic principle employing two equal size pumping gears lends itself to wide flexibility in designing custom pumps. You name the P.S.I., the G.P.M., the port arrangement required, plus other data and we'll work with you in developing rugged, dependable equipment.

MANY STANDARD ROPERS ARE ADAPTABLE TO YOUR NEEDS

With a large selection of both standard and special units from which to choose, substantial savings in designing and engineering costs can be affected. A look at your specifications will tell us if such standard Ropers can be adapted or modified for your needs

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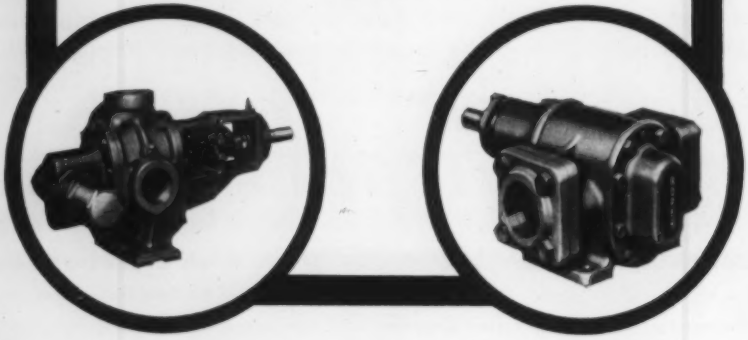
"HOW TO SOLVE PUMPING PROBLEMS"

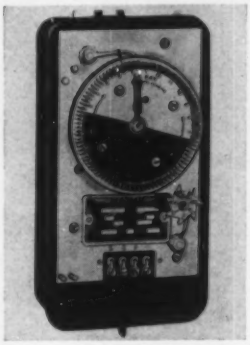
ROPER
Rotary Pumps

GEO. D. ROPER CORPORATION, 246 BLACKHAWK PARK AVE., ROCKFORD, ILL.



New Parts

and 48 "off" operations per day. Control dial, with 15-minute graduations, is used to set up daily operating schedule. Running periods are set by sliding, self-contained, nonremovable trip levers in or out on the dial. Calendar cut-out device, available as an accessory, makes switch completely se-



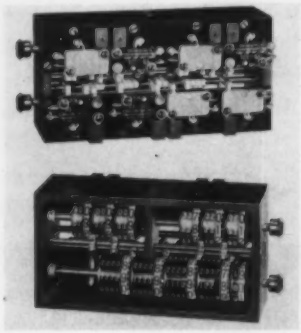
lective for all days of the week. Mechanism is powered by a heavy-duty, synchronous industrial motor. Capacity is rated at 1000 w, 60 cycle ac. Action is single-pole, double-throw. **Zenith Electric Co.**, Dept. MDC, 152 W. Walton St., Chicago 10, Ill.

Circle 786 on page 19

Programmer Counter

for missile and other control applications

Programmer closes from one to eight or more switches at selective predetermined settings within a given range. Applications include missile guidance systems and starting sequence systems. Unit can be used for other applications where plurality of switch contacts is required at selective predetermined numbers. Setting of numbers is accomplished by rotating cam



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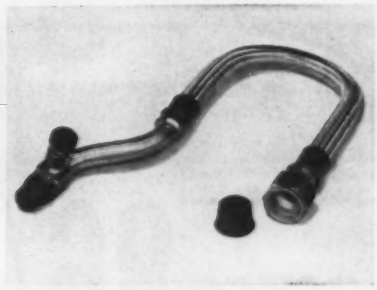
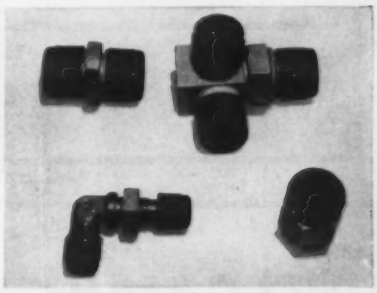
will give you dozens of ideas for protecting products like these

JUST PUSH THEM IN . . . OR PUSH THEM ON
Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside or outside of threaded or plain fittings. Threaded styles are knurled to screw on or off with ease. Made of tough, flexible Polyethylene, CaPlugs are unaffected by most chemicals, acids and solvents . . . will not collapse, chip, break or shred.



"KID GLOVE" PROTECTION WITH A DUAL PURPOSE
Here's how Resistoflex Corp. makes two-fold use of CaPlugs "to protect critical threads and machined surfaces and to keep the interiors of hose assemblies clean and dust-free." Says Resistoflex, "CaPlugs prove most effective for both functions as well as being particularly easy to install."



COUNTLESS USES BY THOUSANDS OF USERS
Bell Aircraft Corp. applies both threaded and non-threaded CaPlugs to a wide variety of parts (such as these) in the manufacture of guided missiles, electronic components, rocket engines and servomechanisms. Throughout industry, many a company has found that CaPlugs provide the perfect answer to practically every closure need.

MAKES A PRODUCT LOOK ITS "SUNDAY BEST"
On this Alemite Accumatic Valve, colorful red CaPlugs add snappy eye appeal and indicate care of manufacture. Says Stewart-Warner Corp., "CaPlugs help impress the customer with the steps that have been taken to protect the equipment and convince him of the continuing need for protecting lubricants against contamination."

THERE'S A CAPLUG THAT WILL DO THE TRICK *You name it! With numerous styles (threaded and non-threaded) stocked in over 500 sizes, "off-the-shelf" deliveries can be made from a 35,000,000 inventory to answer your immediate requirements promptly. You get closures that are right for your jobs . . . right on time.*

GET A FREE BOX OF CAPLUGS, DETAILS AND PRICES BY MAILING THIS COUPON

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2207 Elmwood Ave., Buffalo 23, N. Y.

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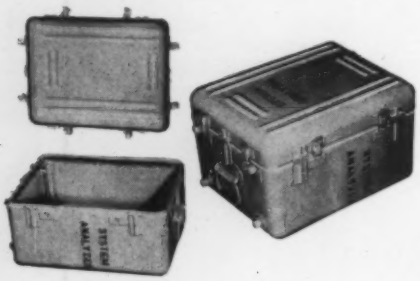

MIL-Spec

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Circle 557 on page 19

RIFLE MAKER SAVES 86%

with **GRC** DIE CASTING

Illustrated rifle part die cast in one piece by Gries not only costs 86% less than former 3-piece assembly, but is actually superior—more precise, better looking, with no assembled parts to loosen. By die casting in one piece, and in one automatic operation, substantial savings in time and money are realized. Designs can be simplified to reduce or eliminate machining and assembly. Quick deliveries on quantities of 100,000 to many millions.

NO MINIMUM SIZE!

Maximum length: 1¾"
Maximum weight ½ oz.

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GRIES WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

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32 Second St., New Rochelle, N. Y. • NEw Rochelle 3-8600

Circle 558 on page 19

New Parts

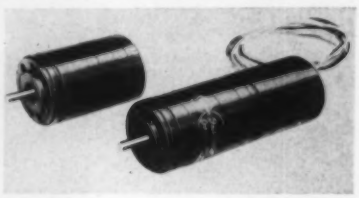
rings to number desired. Speed is 500 rpm at input shaft. Temperature range is −60 to 85 C. Unit conforms to military specifications covering salt spray, humidity, heat and cold, and fungus. **Durant Mfg. Co.**, 1933 N. Buffum St., Milwaukee 1, Wis.

Circle 787 on page 19

Motor Gearheads

for use with size 11 motors

Four gearheads are designed for maximum flexibility in servomechanical devices and other control systems. They meet the need for extended ratios, special sizes, off-center shaft positions and other



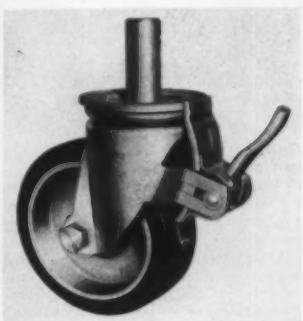
mechanical requirements. All four have operating load torque of 25 oz-in., starting torque of 0.005 oz-in. **Bowmar Instrument Corp.**, 2407 Pennsylvania St., Ft. Wayne, Ind.

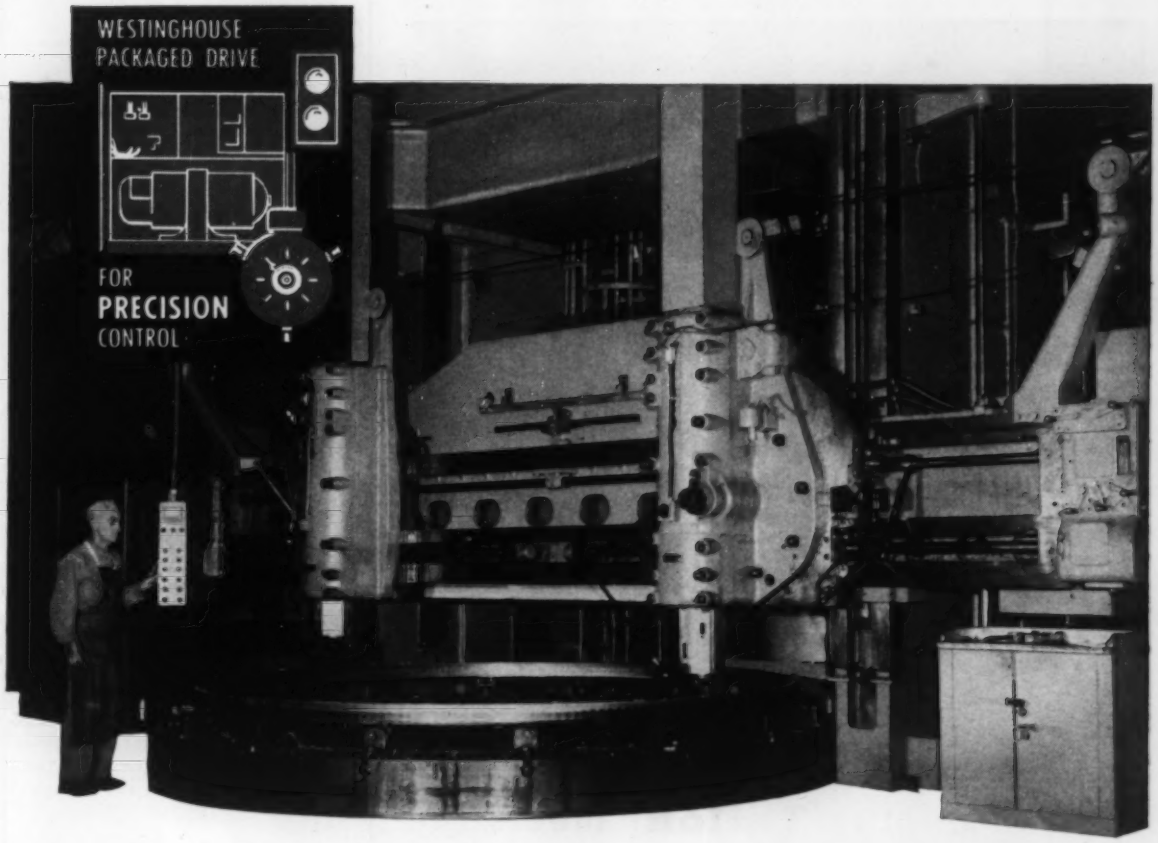
Circle 788 on page 19

Heavy-Duty Caster

has dual brake and wide choice of wheels

FH900 heavy-duty scaffold caster with dual brake is for engine stands, scaffolds and general industrial use. Cantilever brake simultaneously locks both swivel and wheel to prevent scaffold "walking." Wide-face 8-in. diam wheels





"Adjustable-speed Westinghouse AV-DRIVE tripled production on our 14′ boring mill,"

says Chief Engineer, Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Burnham, Pa.

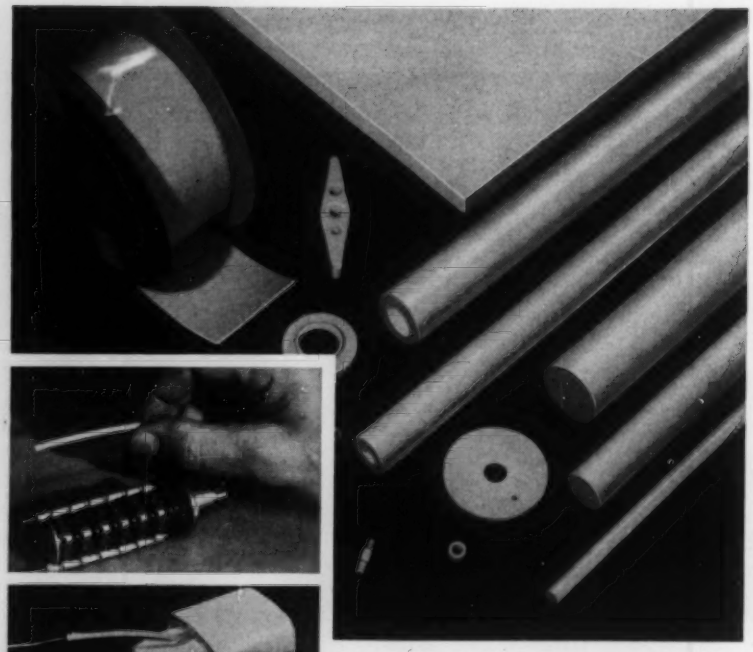
A twist of the dial at the pendant operator's station controls a speed range of ½ to 22¼ rpm on this vertical boring mill equipped with Westinghouse AV Drive. Precision control of the 75-hp Westinghouse d-c motor produces the work formerly done by *three* belt-driven mills operated by Standard Steel Division.

In addition to the precision and adjustable speed necessary for turning, facing and boring weldless steel rings, the 19 Westinghouse AV Drives now in use give Baldwin-Lima-Hamilton the versatility needed for profitable use of their huge metal-working facilities.

To learn how the versatile Westinghouse AV Drive can make your production more profitable, call your local Westinghouse representative or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-22014

AV Drive, providing on-the-spot conversion of plant distribution system a-c voltage to the required direct current for precision control of the drive motors.

YOU CAN BE SURE...IF IT'S Westinghouse



Polypenco® Teflon stock shapes and fabricated parts. (left below) Aircraft high voltage pulse transformer uses Polypenco Teflon Tape insulation for interlayer, case lining and terminal wrapper. (left above) Polypenco Teflon Spaghetti Tubing used in miniature rotary tap switch combines high dielectric strength in thin sections with resistance to soldering heats.

Highest quality **Teflon*** meets the strict requirements of electronic designers

The increasing use of Teflon in the electronics and electrical field has revealed the need for Teflon with standard, unvarying high quality. To meet these needs, Polypenco Teflon is subjected to rigid in-process testing throughout manufacture, insuring uniform controlled density and dimensional stability.

Teflon's Outstanding Properties

- Dielectric Constant.....2.0
- Power Factor.....0.0005
- Dissipation Factor.....0.0002
- Dielectric Strength, Volts/mil..400-500
- Volume Resistivity.....10^{15} ohm-cm
- Surface Resistivity 100% R.H.....10^{13} ohm
- Water Absorption.....Zero
- Fungus Resistance.....Excellent
- Services entire frequency range
- Arc Resistance — Good, leaves no carbon path regardless of time of exposure.

Parts and components fabricated from Polypenco Teflon shapes give you top performance in the most critical applications because Polypenco Teflon brings you *all* the desirable characteristics of this versatile material.

Stock Shapes Readily Available

Polypenco Teflon is furnished in rod, tubing, tape and sheet in a wide range of sizes. Polypenco Spaghetti Tubing is available in 26 AWG wire sizes and is made in 10 fade-proof colors. Nationwide stocking and service points assure prompt delivery. The name of your nearest distributor is immediately available on request.

Fabricating Service

Custom fabricated parts are available from The Polymer Corporation of Penna., engineered for the best in design, quality and tolerances.

Write for latest data and bulletins.

THE POLYMER CORPORATION OF PENNA.

Reading, Pa.

Export: Polypenco, Inc., Reading, Pa., U.S.A.

*DU PONT TRADEMARK

POLYPENCO

POLYPENCO nylon, POLYPENCO Teflon*, FERROTRON® and NYLATRON® GS

Circle 560 on page 19

New Parts

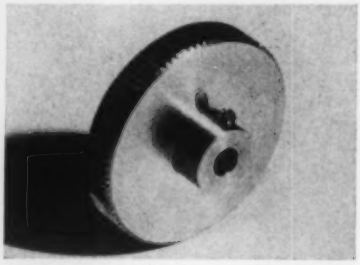
are available with either hard or cushion tread for all floors. **Faultless Caster Corp.**, 1521 N. Garvin St., Evansville 7, Ind.

Circle 789 on page 19

Knurled Knobs

in three shaft sizes

Type-BG precision knurled knobs are available in ⅛, 3/16 and ¼-in. diam shaft sizes. Outside diam-



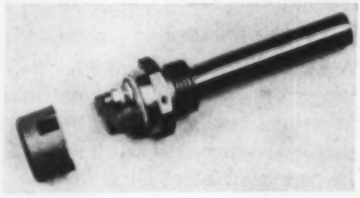
eters range from 1 to 2 in. Material is No. 303 stainless steel, clear passivated. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, N.Y.

Circle 790 on page 19

Temperature Controller

provides operating ranges from −100 to 1100 F

Tempswitch temperature controller provides several operating ranges from −100 to 1100 F. Unit is furnished in ac or dc with differential at setting point of ±2 per cent. Switch can provide differ-



ential as close as 1 F. Case is stainless steel and plain cartridge, flanged or threaded mountings are available. **Scaico Controls Inc.**, P. O. Box 41, Delanco, N.J.

Circle 791 on page 19

Miniature Potentiometer

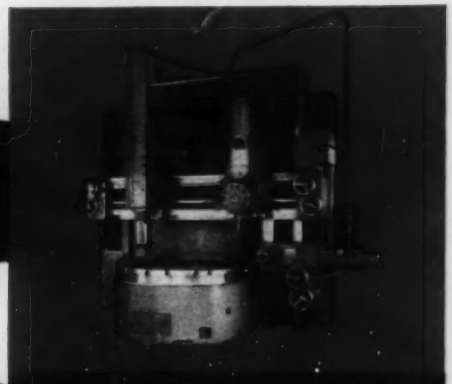
has 2.0-w power rating

Model 220 Trimpot Jr. circuit-balancing potentiometer has humidity-proof construction, excellent shock,

For today's advanced

machine tools

Such as BULLARD MAN-AU-TROL
and CUT-MASTER VERTICAL TURRET LATHES

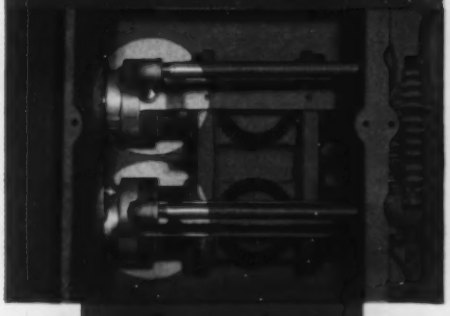


Above: Maxitorq Single and Double Electric Clutches on Bullard Cut-Master Model 75 Machines with single angular turning attachment.

Below: 2 Maxitorq Single Electric Clutches on Bullard Man-Au-Trol Model 75 Machines with double angular turning attachment.

New MAXITORQ ELECTRIC CLUTCHES

Compact, simple in design and construction, fully service-tested, this entirely new clutch design is ideally suited . . . as these Bullard applications show . . . to the new requirements of machine control. Here are the LONG-PROVED advantages of the famous Maxitorq Floating Disc Clutch, now electrically operated, and with these outstanding features . . .



- Either WET or DRY operation
- STATIONARY coil . . . no brushes
- NO ADJUSTMENT . . . POSITIVE ENGAGEMENT
- STANDARD MAXITORQ DISC PAC
- FLOATING NEUTRAL . . . NO DRAG
- FULL POWER TRANSMISSION
- USED AS CLUTCH OR BRAKE
- FULL RANGE SINGLE, DOUBLE TYPES
- UP TO 788 LB. FT. OF TORQUE
- Operates on 110 V.AC rectified to 90 V.DC . . . other voltages on special order

Write Dept. MD-6 for full information.

THE CARLYLE JOHNSON MACHINE COMPANY

MANCHESTER, CONNECTICUT

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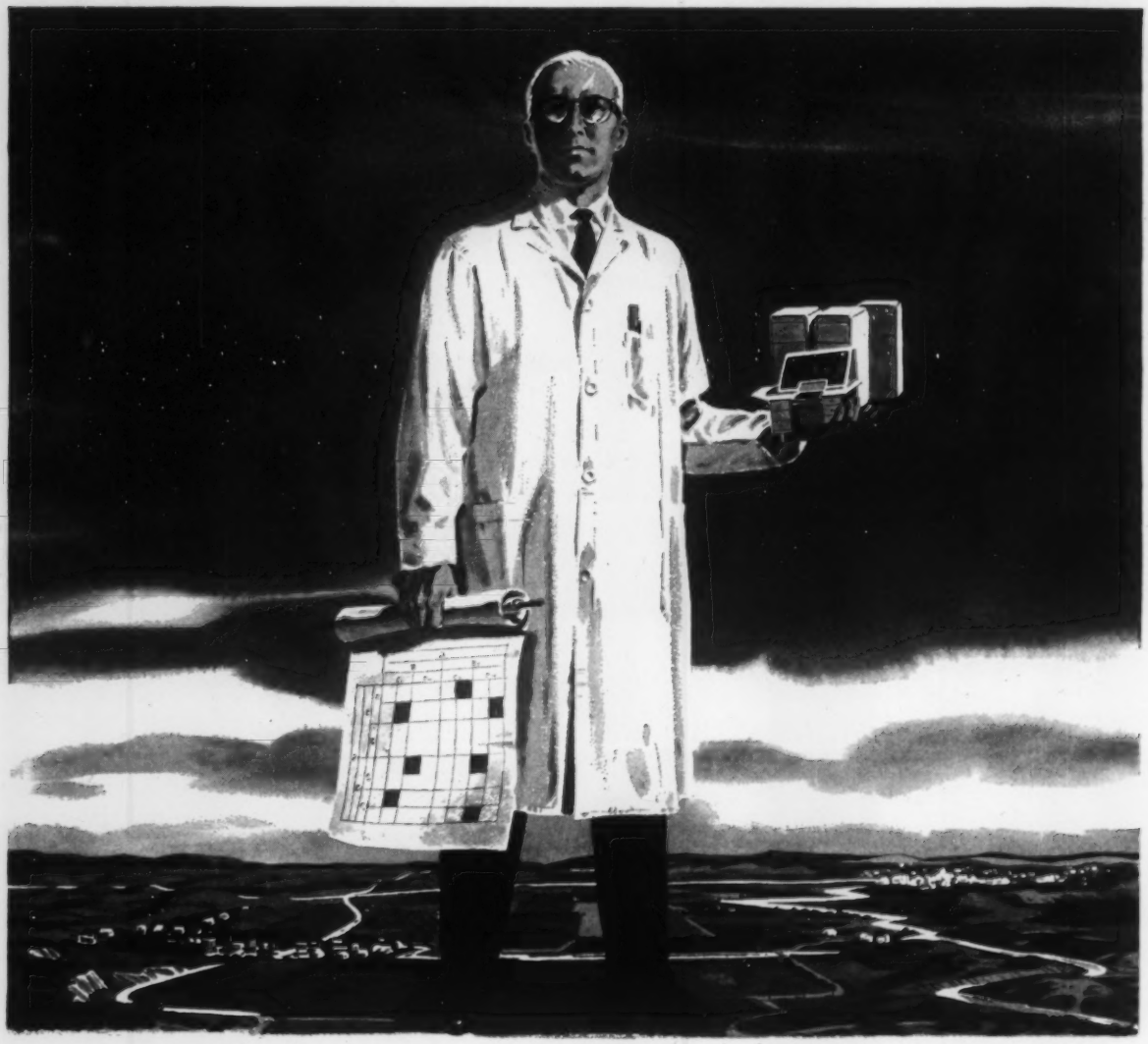

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all three help assure National Seals are best engineered

Univac you know, experience you know; the Latin Square? An ancient, half-forgotten solver of problems having many variables. Today, National Seal engineers use it to reduce exploratory engineering time as much as 75%.

Old, new, time-tested and visionary—National Seal engineers embrace every approach that can help keep National Seals the best engineered in America. Results have been good. Syntech®, the milestone in synthetic rubber seals and Micro-Torc®, major forward step in leather seals, are but two examples.

National Seal's advanced engineering, in plant or field, is ready now to help you solve sealing problems. This help is yours for a telephone call.

VITAL: Whatever seals you buy, save trouble and expense later on by specifying them "on the board." For safety, have specifications checked by a National Seal engineer.

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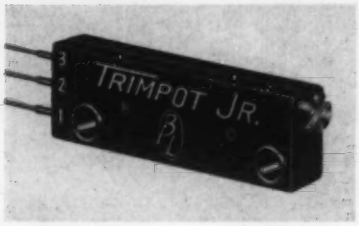
Downey (Los Angeles Co.), Calif., 11634 Patton Rd., TOpaz 2-8163 • Indianapolis, Indiana, 2802 North Delaware St., WAlnut 3-1535
Milwaukee, Wis., 647 West Virginia St., BRoadway 1-3234 • Newark, N. J., 1180 Raymond Blvd., MItchell 2-7586

4228

acceleration and vibration characteristics, and power rating of 2.0 w. Mounting is with No. 2-56 screws through stainless-steel eyelets on ¾-in. centers, and 17 units can be mounted in 1 sq in. of panel space. Tinned copper leads 1½ in. long by 0.016-in. diam permit use



of either printed circuit or standard wiring techniques. Maximum operating temperature is 175 C. Unit meets humidity specification MIL-E-5272A and is impervious to salt spray, fungus, sand and dust. **Bourns Laboratories Inc.,** 6135 Magnolia Ave., Riverside, Calif.

Circle 792 on page 19

Insulating Couplings

withstand pressures to 1100 psi

Pesco permanent insulating couplings, consisting of molded Nylon threaded sleeve in a steel sleeve, serve as dielectric connections between sections of piping on gas distribution systems. Couplings insure electrical isolation, eliminate corrosion, and withstand bending, side-thrust and shock. Locking device prevents couplings from turning or slipping within steel sleeve. Units withstand pressures to 1100 psi and are unaffected by temperatures to 300 F. Units are available in all sizes from ¾ to 2 in. **Plastic Engineering & Sales Corp.,** Box 1037, 2628 St. Louis Ave., Ft. Worth, Tex.

Circle 793 on page 19

Centrifugal Pump

for immersion in liquid to 5¾ in.

Midget Hi - Flow vertical submerged-type centrifugal pump is suitable for supplying coolant for machine tools and light machinery, for use where dirt or abrasives

(*Continued on Page* 252)

If it's HOT or DRY

USE 'DIAMOND H'

SERIES R

RELAYS

Where the temperature hits 200°C. or the dry circuit is downright arid, your best bet for reliability is a "Diamond H" Series R miniature, hermetically sealed, aircraft type relay. Their shock and vibration resistance you may take for granted.

On the other hand, Series R relays (4 PDT) also give excellent reliability at —65°C. and will carry up to 10 amperes in power circuits . . . or even 20 amperes for short life requirements. In other words, they offer an extremely wide range of performance characteristics from which "Diamond H" engineers will be happy to work out a variation to meet your specific requirements. Just ask.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 20 "G"
Temperature Range:	—55° to +85°C. —65° to +125°C. —65° to +200°C.
Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,000 V., RMS
Operating Time:	24 V. models 10 ms. or less; dropout less than 3 ms.
Contacts:	30 V., D.C.; 115 V., A.C.; 2, 5, 7½ and 10 A., resistive; 2 and 5 A. inductive. Minimum 100,000 cycles life. Low interelectrode capacitance—less than 5 mmf. contacts to case; less than 2½ mmf. between contacts. Special Ratings: to 350 V., D.C., 400 MA., or other combinations including very low voltages and amperages or amperages to 20.
Operational Shock Resistance:	30, 40 and 50 "G" plus
Mechanical Shock Resistance:	up to 1,000 "G"
Mounting:	9 standard arrangements to meet all needs —plus ceramic plug-in socket.
Size:	1.6 cu. in.
Weight:	4 oz. or less

Bulletin R-250 gives more complete data. Send for a copy.

THE HART MANUFACTURING COMPANY

118 Bartholomew Ave., Hartford, Conn.

Circle 563 on page 19

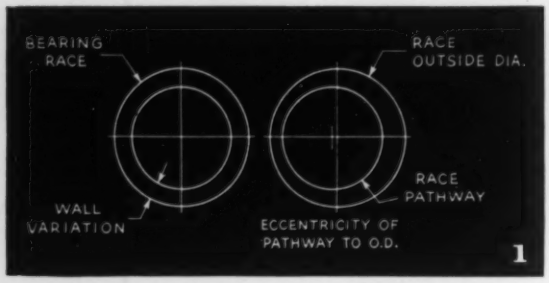
The Inside Secrets of Smoother Performance

How HYATT quality controls assure race concentricity, roller diameter uniformity and other internal essentials of smoother, longer-lived cylindrical roller bearings . . .

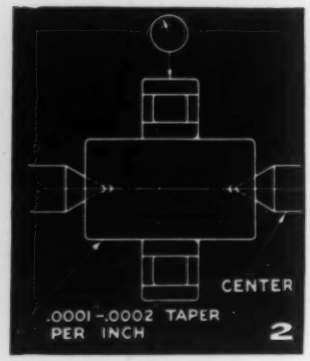
The running accuracy and smoothness of a roller bearing is governed primarily by its internal dimensions and clearances. The most important of these are:

1. CONCENTRICITY OF RACE DIAMETERS

Eccentricity of race diameters is usually interpreted in terms of *wall variation*, Figure 1, on the individual components and in terms of *radial run-out* on the assembled bearing. The



assembled bearing is usually mounted on an arbor, Figure 2, having a slight taper (.0001″ to .0002″ on the diameter per inch of length) and the radial run-out indicated as shown. The radial run-out is the difference between the minimum and maximum readings obtained when rotating the outer race one revolution with the arbor stationary for outer race radial run-out, or rotating the arbor one revolution with the outer race stationary for inner race radial run-out.

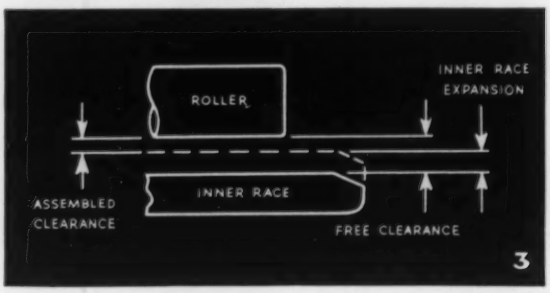


2. UNIFORMITY OF ROLLER DIAMETERS

Another factor governing running smoothness is *roller diameter uniformity*. This is usually obtained by segregating the rollers into diameter variation classes of .00005″, .0001″, or .00015″, depending on the bearing size and the nature of the application, and assembling only rollers of the same group into a given bearing. Gauging for this segregation necessarily rejects excessive taper.

Uniformity of roller diameters is important for another purpose. It provides the user with a bearing in which the internal diametral clearance is controlled within the closest possible limits. The rollers are matched with races which are segregated for pathway size in a fashion similar to the rollers, usually to twice the diameter limits of the rollers. The internal clearance can thus be manipulated at will by combining various diameter classes of races and rollers; but once a particular range is selected, it will remain constant within the combined limits of the roller and race pathway diameter limits. Here, again, a tapered condition of the race pathway is automatically rejected.

Obviously, the internal clearances of commercial bearings must be standardized for the practical reasons of cost and availability, but the clearance values have been so selected that under the specified fits the *running* clearance is at the most desirable minimum, depending on bearing type and size. Figure 3 (magnified).

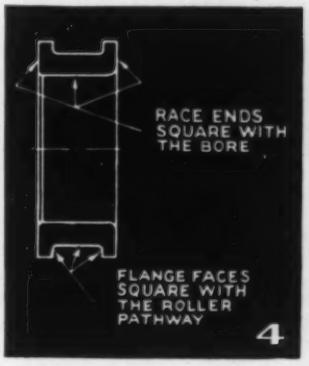


Checking wall variation, flange run-out and race end squareness on combination gauge.

3. SQUARENESS OF ROLLER ENDS AND FLANGE FACES

One other tolerance that contributes to the running efficiency of HYATT Hy-Load Series Bearings of the flanged race type is the *squareness of roller ends with roller diameters* and the *squareness of flange faces with the race pathways.*

Flanged race bearings are commonly used for locating shafts laterally and for running conditions of light and intermittent thrust load. For best operating results, the ends of the rollers must be flat and square with the diameter within a matter of tenths. The lateral clearance between the roller and the race shoulders must also be held to a minimum. This means close tolerances on roller length and race pathway width, and the flange face, Figure 4, must be square with the roller pathway. When all these conditions are satisfied, there will be no tendency for the rollers to skew and raise the operating temperature of the bearing, nor will there be any unusual force on the separator or cage with a tendency toward wracking and noisy operation.



The *side run-out* of the individual races or the *out-of-square* of the ends with the fitting diameters is also important, especially in applications where a number of parts are held together endwise and where the pressure might be sufficient to tilt the race, creating a condition of excessive taper on the roller pathway with consequent roller skewing and the development of excessive heat and noise.

All these internal dimensions and clearances are so carefully controlled that HYATT Hy-Roll Bearings have built an unsurpassed reputation among design engineers for exceptionally long, smooth and trouble-free performance.

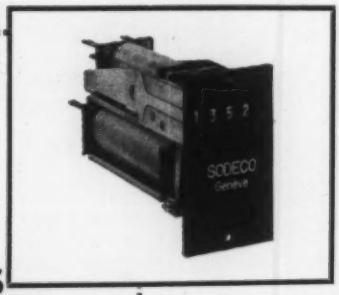
YOU WILL FIND MORE DETAILS

in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your design requirements. Remember, HYATT is America's first and foremost maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT *HY-ROLL BEARINGS* FOR MODERN INDUSTRY

Team SODECO Electric Reset Counters *up* . . . CONFIDENTLY



You know they'll perform dependably. You can team up 100 SODECO Electric Impulse Counters, (we'll be glad to show you how) send a single reset impulse, and all will reset to zero—instantly, simultaneously, *reliably*.

There are many other reasons why you want to include SODECO Electric Reset Impulse Counters in your design. For instance:

- They're FAST — count up to 25 impulses/sec.
- They're COMPACT—model illustrated measures only 1⅜" x 2⅜" x 4⅛" and is suitable for flush mounting.
- They're available in 4, 5 and 6 digit models.
- They have a LOW POWER REQUIREMENT—they've been operated in electronic circuits.

SODECO Counters may be the answer to your counting problem. Write for full information to:

LANDIS & GYR
INCORPORATED
45 West 45th Street New York 36, N. Y.

Circle 565 on page 19

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WHITEPRINT COPYMATION

Make exact-copy whiteprints quickly, easily—at half the cost of blueprinting. Save time, work and money. With the modern P&H SPEEDMASTER, anyone can print and develop exact same-size black-line and colored-line whiteprints of drawings, charts, reports, letters, forms, or any translucent original whether written, typed, printed or photographed. Has latest P&H developments. Pays for itself over and over again.

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Progressing with the Reproduction Industry Since 1937
MFRS. OF WHITEPRINT, BLUEPRINT & PHOTOCOPY EQUIPMENT

Circle 566 on page 19

New Parts

(*Continued from Page 249*)

are present in liquid, and for light transfer work. It is equipped with integral ⅛-hp, three-phase or 1/10-hp, single-phase motor. Motor is totally enclosed with NEMA standard flat-face mounting and is designed for continuous duty. Unit is designed for immersion in liquid to 5¾ in. with motor mounted 2 in. above maximum liquid level. Concentric design adapts unit to round-hole installation. **Brown & Sharpe Mfg. Co.**, Providence 1, R.I.

Circle 794 on page 19

Miniature Gyro

has damping ratio of 0.1 of critical

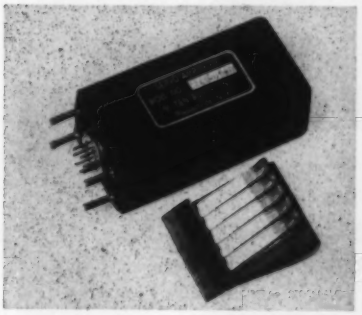
Model 55,000 floated-rate gyro meets environmental conditions encountered in missiles. Accuracy better than ±½ per cent full scale is obtained while subjected to severe vibration environment. Unit is available in maximum-rate ranges from 1 to 1000 deg per second. Gyro incorporates inductive signal pickoff. Unit is completely filled with flotation fluid to reduce load on gimbal bearings and provide damping. Damping ratio can be maintained within 0.1 over temperature range of −55 to 85 C. **Norden-Ketay Corp.**, Commerce Rd., Stamford, Conn.

Circle 795 on page 19

Servo Amplifier

exceeds requirements of MIL-E-5400A

Model 1800-0500 Tramp is a high-temperature, miniaturized, hermetically-sealed, plug-in transistor



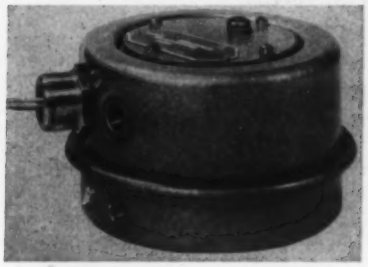
servo amplifier. It receives signals from a synchro control transformer and operates size 15, 400-cycle, 6.1-w servomotor or equivalent. Unit exceeds environmental requirements of MIL-E-5400A. Temperature range (continuous) is −55 to 100 C, with intermittent rating to 125 C. Connector is hermetically-sealed, 7-pin, plug-in type. Unit is mounted with four No. 6-32 weld studs. **M. Ten Bosch Inc.,** Pleasantville, N.Y.

Circle 796 on page 19

Differential Switch

for vacuum and low pressure

Model 2273 differential switch operates relays, solenoids, motor controls and similar devices. It is available in two classes for sensing pressure differences from 15 in. of water below atmospheric pressure to 80 in. above. Fixed



actuation value ranges from 0.2 to 2 in. of water, depending on switch setting. Reference pressure must be air or inert gas; variable pressure can be liquid or gas. Switch is insensitive to jarring or vibration and operates in any position. Single-pole, double-throw snap-action switching element is rated for ac and dc. **Barksdale Valves,** Pressure Switch Div., 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle 797 on page 19

NOW! *Adjustable Diameter and Open*

THOMSON

BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**

Precision Series "A" and Low Cost Series "B" BALL BUSHING.

Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION · ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE · LASTING ALIGNMENT

The various types cover a shaft diameter range of ¼" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.

Dept. E, MANHASSET, NEW YORK

Also manufacturers of NYLINED Bearings
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Circle 567 on page 19

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POWER
for the
oil and **chemical**
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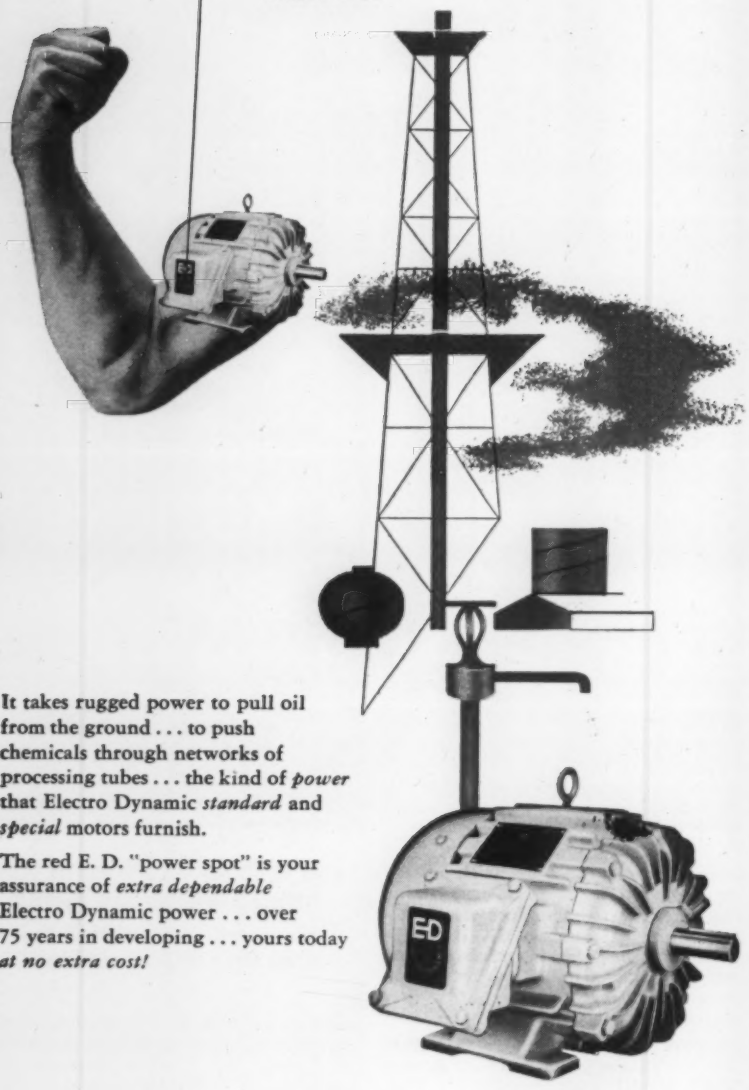


It takes rugged power to pull oil from the ground . . . to push chemicals through networks of processing tubes . . . the kind of *power* that Electro Dynamic *standard* and *special* motors furnish.

The red E. D. "power spot" is your assurance of *extra dependable* Electro Dynamic power . . . over 75 years in developing . . . yours today *at no extra cost!*

EXPLOSION-PROOF

ELECTRO DYNAMIC
DIVISION OF GENERAL DYNAMICS
CORPORATION
BAYONNE, NEW JERSEY

Circle 568 on page 19

ENGINEERING DEPARTMENT
EQUIPMENT

Slide Rule

in cylindrical form has 66-in. scale

Cylindrical calculator with a high degree of accuracy has scales spiraled around a tube, achieving graduations equal to those of a 66-in. slide rule. Calculator solves all problems involving multiplication, division, proportion, percentages,

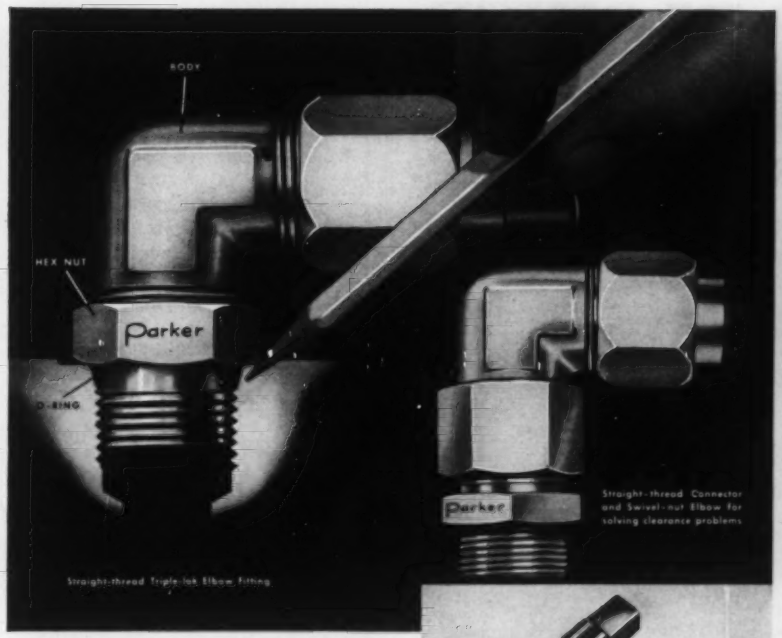
logarithms, roots and powers. Plastic-covered scales are resistant to wear and moisture. Since all parts of the instrument are made of metal, there is no possibility of warping or distortion. **Arthur F. Smith Co.**, 311 Allexander St., Rochester, N. Y.

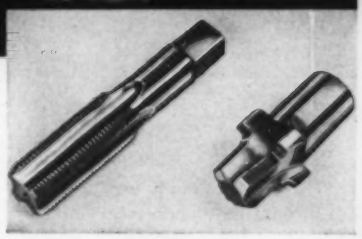
Circle 798 on page 19

Tachometer Calibrator

provides counting speeds to 50,000 per second

Model ST-901 tachometer calibrator is basically an electronic decade-type counter combined with electronic adjustable-speed drive. Tachometer under test is driven at a speed infinitely adjustable by means of a ten-turn potentiometer. For rapid production testing, a pushbutton switch selects any one of five predetermined speeds. Driving speed is continuously displayed with accuracy of ±1 rpm, plus line





Precision thread-tapping and counterboring tools for making accurate *straight*-thread boss (to receive these new Parker *straight*-thread fittings) are now available with machining drawings from Parker.

New Parker *straight*-thread fittings solve your leakage problems

Now you can forget about high-pressure hydraulic problems resulting from tapered pipe threads. Forget about leakage . . . about the danger of cracking or distorting valve bodies by over-tightening the fittings . . . about damaged threads from over-tightening to obtain proper positioning. Forget about messy pipe "dope".

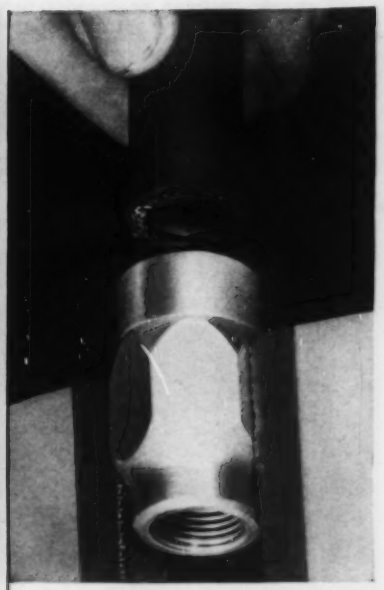
You can eliminate all of these problems by using new Parker *straight*-thread fittings with positive O-ring seals. (See illustration above.)

Parker *straight*-thread fittings are now being supplied in response to the growing demand for this new type of leakproof, trouble-free connection. They are shorter and have smaller hexes than the AN fitting for the old AND 10050 boss. *Straight* threads are available on *Triple-lok* (the industrial standard flare tube fitting) and on *Ferulok* (flareless fitting for heavy steel tubing).

This is another example of Parker's pioneering leadership in the field of hydraulic fittings. Write for Catalog.

TUBE AND HOSE FITTINGS DIVISION
Section 417
The Parker Appliance Company
17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid system components



Now enjoy advantages of rubber-covered hose without stripping . . .

Use new Parker NO-SKIVE fittings

Stop stripping hose covers! New NO-SKIVE *Hoze-lok* fittings require no stripping of rubber-covered hydraulic hose. They're faster, easier-to-use . . . *and re-usable.*

Two simple steps complete the make-up: (1) Dip end of hose in oil and screw into socket counter-clockwise until hose reaches end of recess in socket. (2) Dip nipple in oil and push into socket and hose, turning clockwise to engage thread. Screw all the way in.

During step (1), the lead thread of the socket cuts through the rubber cover of the hose. This permits the threads following it to contact and grip the wire braid. It will hold beyond hose-bursting pressures . . . also under severe vibration conditions.

Send for Bulletin 4433. Mail the coupon for complete information about these new Parker *Hoze-lok* fittings. Find out how you can simplify and speed your hose assemblies.

TUBE & HOSE FITTINGS DIVISION
Section 417
The Parker Appliance Co.
17325 Euclid Ave.
Cleveland 12, Ohio

☐ Please send me your new Bulletin 4433 about NO-SKIVE Parker Hoze-lok fittings.

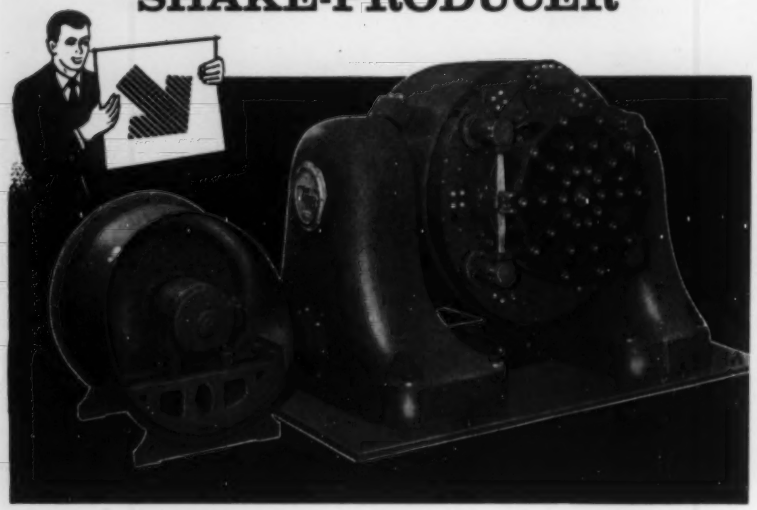
Name_____

Company_____

Address_____

City State

a SPENCER BLOWER cools this powerful "SHAKE-PRODUCER"



SPENCER blower on MB Vibration Exciter

This vibration machine (more formally designated an "electro-dynamic exciter") exerts a force of 12,500 lbs. . . . is used to test guided missiles, aircraft and other airborne equipment.

In designing the machine, MB engineers faced this problem: heat generated by the electrical fields was tremendous. How could this heat be dissipated most efficiently . . . in a continuous, reliable fashion.

The problem was turned over to SPENCER engineers. Their solution: a specially designed single stage, double inlet 5 HP blower, mounted as shown above.

Assistance of this type is typical of SPENCER'S cooperation in designing and manufacturing blowers and vacuum products to meet design engineers' special requirements. They'll be glad to help solve any of your needs in delivery of high volume, low pressure air.

Standard Capacities of Spencer Blowers
⅓ HP to 1,000 HP
Up to 20,000 CFM
4 oz. to 10 lbs. pressure

Two Catalogs to Aid the Designer

"132 UNUSUAL USES OF SPENCER VACUUM"

Illustrates and describes how Spencer Vacuum is used in industries from A to Z.

"TURBO DATA BOOK"

Supplies application data on Spencer Blowers. Request Bulletin 107-C.

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

Circle 570 on page 19

Engineering Equipment

frequency error. Counter can be used for other purposes such as checking inverter frequency and telemetering switch counts. Counting speeds up to 50,000 per second are provided. Electronic pick-up is supplied to permit checking rotational or linear speed of motors and gear trains. **Servo-Tek Products Co.**, 1086 Goffle Rd., Hawthorne, N. J.

Circle 799 on page 19

Whiteprinting Machine

reproduces at speeds up to 32 fpm

Crusader 42-in. automatic whiteprinting machine reproduces, at speeds up to 32 fpm, anything typed, written, drawn or photographed on reasonably translucent material. Exposure of sensitized material is accomplished by use of heavy-duty 4000-w high-pressure

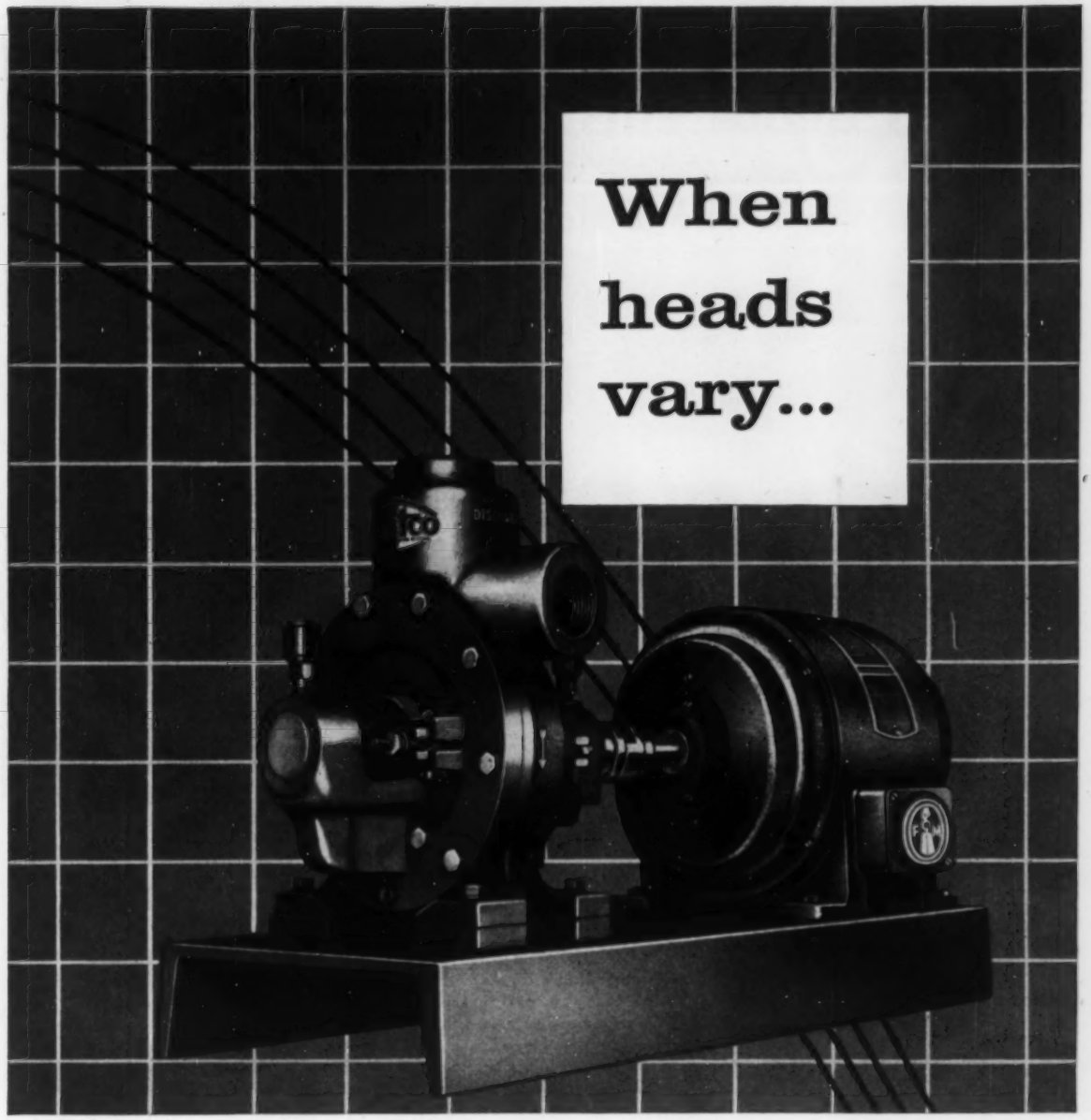
mercury lamp; dry development of prints by ammonia vapors is instantaneous. Printing, copy separation, development, print delivery and stacking are all automatic. Wind-up device is available as an accessory for continuous yardage operation from rolls. **C. F. Pease Co.**, 3998 N. Rockwell St., Chicago 18, Ill.

Circle 800 on page 19

Pencil Pointer

sharpens any drawing lead

This motorized unit sharpens any drawing instrument from pencil to beam compass with any type of point desired. Built-in wiping pad is provided. Opening the lid starts shaded-pole motor which vibrates filing plate for sharpening lead; closing lid shuts off motor. Medium-impact plastic case is available in six colors. File plates and wip-



Install a Fairbanks-Morse Westco peripheral pump . . . and make sure of efficiency with little or no loss of capacity!

How? Through original F-M Westco design—these pumps deliver approximately the same capacity when discharging against high pressure or low pressure—and all at 1750 rpm.! Another important point: by featuring a multi-vaned impeller, these Westco peripheral pumps deliver multi-stage performance from a single-stage pump.

You'll find Westco peripheral pumps ideal as integral parts of machines, units or systems . . . such as circulating hot water, ice water or brine . . . or for service on clear water, sump, solvents or chemical fluids, feeding filters or boilers, or as booster pumps. Capacities to 200 gpm., heads to 600 feet. For complete information and assistance contact your F-M Pump Dealer, or write today to Fairbanks, Morse & Co., Dept.MD-613, 600 South Michigan Avenue, Chicago 5, Illinois.

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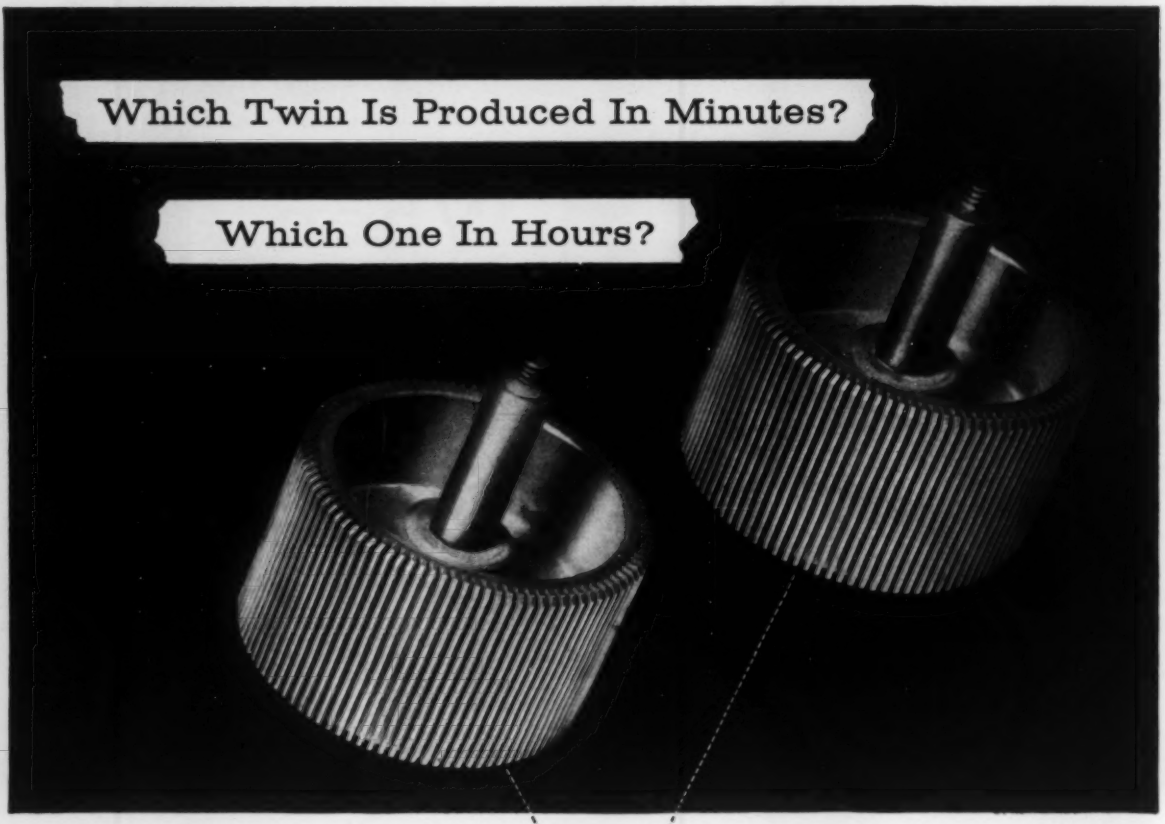
a name worth remembering when you want the BEST

PUMPS • SCALES • DIESEL LOCOMOTIVES AND ENGINES • ELECTRICAL MACHINERY • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS

Circle 571 on page 19



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Edward F. Higgins, Jr. • 102 West Adams Street

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R. W. Fletcher • 2803 Loomis Avenue

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

WILTON, Conn.
Girard L. Palmer • Belden Hill Road

These parts are identical. One, however, is produced in minutes, the other in hours. Parker-engineered die casting makes the difference.

Formerly, this part (shown left above) was machined from the solid. The threaded steel shank was inserted in a separate operation. Numbers on the face (not shown) had to be stamped . . . still another operation. *Total production time per piece was measured in hours.*

Now, this same part, including the steel insert and the face numbers, is produced as a unit by Parker-engineered die casting. Trimming of gate and fins is the only secondary operation. *Total production time per piece is now measured in minutes.*

Here is just another example of the way Parker-engineered die castings save you money.

This skill and experience can solve problems—and save money—on *your* components parts. Just call the nearest Parker sales engineer or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings POWDERED METAL PARTS

Circle 572 on page 19

ing pads are easily replaceable. **Ferance Construction Co.**, Penfield, N. Y.

Circle 801 on page 19

Power Supply

for laboratory applications

Model 7P13 laboratory-type power supply has input voltage of 105 to 125 v, 50 to 60 cps. Three output voltages are available: continuously variable 0 to 300 v dc at 150 ma; continuously variable 0 to negative 150 v dc at 5 ma; and

6.3 v ac at 8 amp. High voltage regulation is ± 0.5 per cent from 20 to 300 v at 0 to 160 ma. Unit is available in cabinet or rack-type mounting. **Western Gear Corp.**, P. O. Box 182, Lynwood, Calif.

Circle 802 on page 19

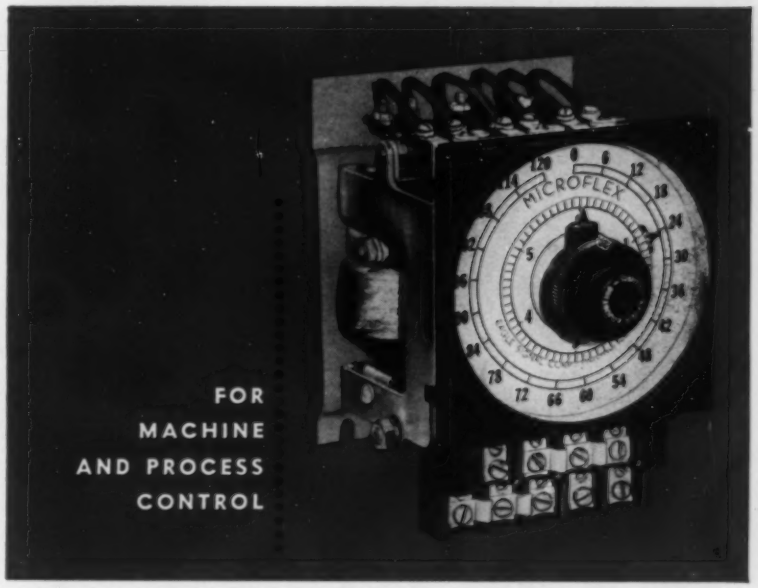
Tachometer Generators

operate from − 55 to 80 C

Motor tachometers and tachometer generators are for use in high-accuracy computers and servo systems as applied to guided missiles, navigation equipment, fire-control computers, bomb directors and other applications. Linearity is 0.12 per cent from 0 to 4000 rpm. Temperature compensation is to ± 0.3 per cent over operating temperature range of − 55 to 80 C. Tachometer generators can be combined with sizes 15 and 18 low-inertia servo motors. **Norden-Ketay Corp.**, Commerce Rd., Stamford, Conn.

Circle 803 on page 19

EAGLE
Microflex Reset Timer



Accurate to 1 Part in 1200

Time settings of pinpoint accuracy are a reality, thanks to the Microflex double dial. It takes one complete turn of the *inner* dial to advance the *outer* dial just one division. That's a 20-to-1 ratio, made possible by the patented Microflex threaded axle and pinion (see sketch). Examples of resultant accuracies are ± 1/60 of a second on a 20-second dial, and ± 1/10 of a second on a 120-second dial.

The Microflex Reset Timer is driven by a heavy-duty industrial synchronous motor. Contacts are tripped closed or open after a preset time interval. Starting and resetting are electrically controlled. Microflex offers over 150 timer operating combinations, plus a wide range of long or short time periods. It's ideal for applications like molding presses, dielectric heating, automatic mixing, die casting machines, machine tools and rubber curing.

Write for free Bulletin 110.

MAIL COUPON TODAY

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. MD-657
MOLINE, ILLINOIS

Please send free Bulletin 110 containing complete data on Microflex Reset Timers.

NAME AND TITLE

COMPANY

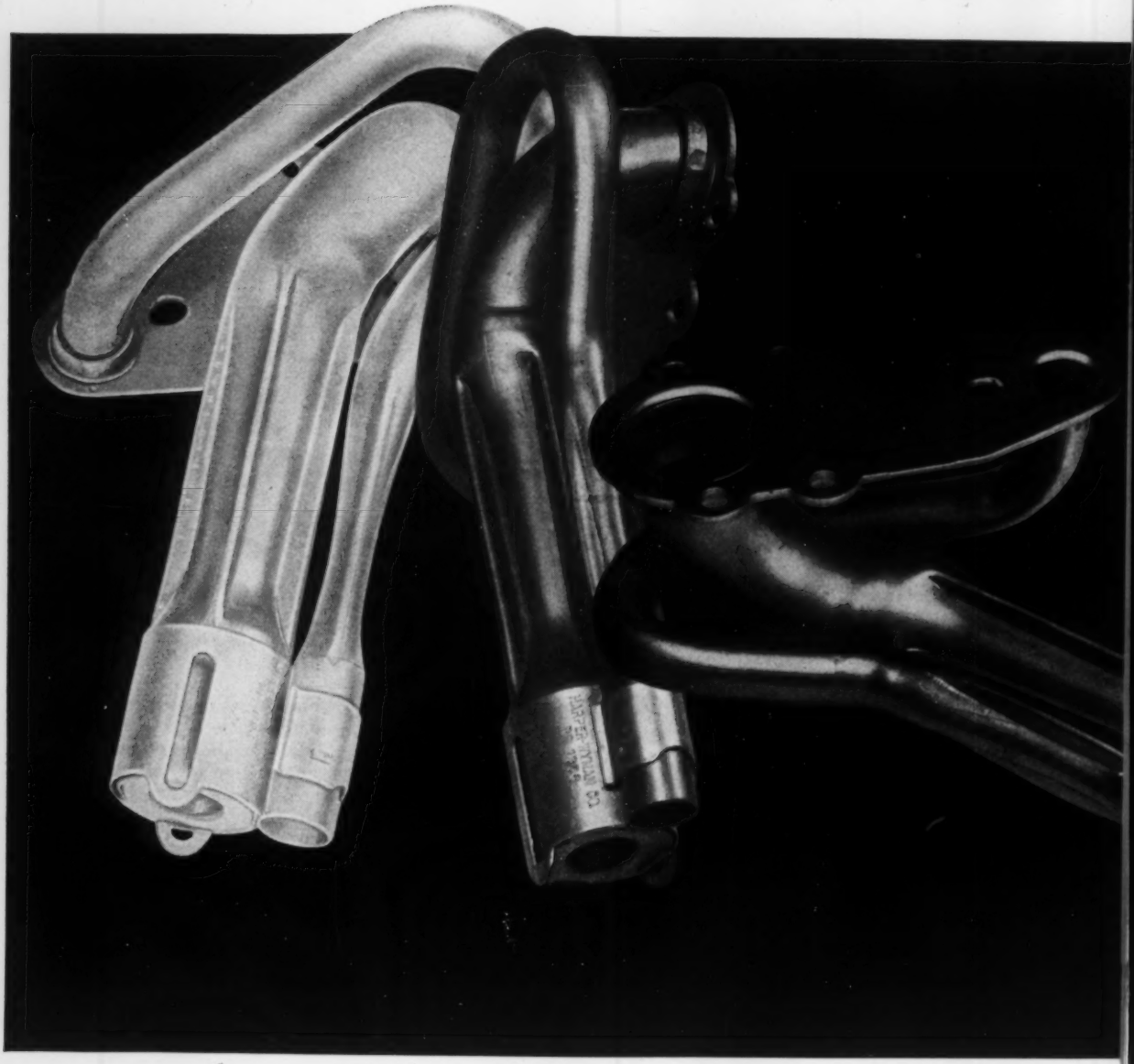
ADDRESS

CITY ZONE STATE

Circle 573 on page 19

Range-burner manufacturer does

REPUBLIC ELECTRUNITE



REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

everything but tie knots in this STEEL TUBING

First, there's a hairpin bend to a 1¼-diameter radius! Then a 4-way crimp to form a finned venturi! Next some punching and notching! Followed by welding!

This is how Harper-Wyman Company turns Republic ELECTRUNITE® Carbon Steel Tubing into the lightweight, easy-to-clean venturi burner tubes used on scores of famous-name gas ranges.

All these severe bending and crimping operations depend on close tolerances on the O.D. and the I.D. of the Republic Steel Tubing to avoid die and mandrel troubles. Uniform, predictable ductility is a must to avoid stretch and collapse as the tubing is severely bent and formed.

Republic ELECTRUNITE Steel Tubing is uniform in wall thickness, fully concentric, and can be furnished with smooth surface finish inside and out. It is supplied in a full range of sizes, wall thicknesses, grades, and ductilities to meet any of your fabricating requirements. Dollar for dollar, your best tubing buy is Republic ELECTRUNITE, the *original* electric-resistance-welded tube.

Let our engineers help you design Republic ELECTRUNITE Steel Tubing into your products to speed production, cut costs, eliminate excess weight and improve product performance. Fill in coupon and mail today.

VOLLRATH COMPANY MAKES STAINLESS STEEL WASHER TUB IN ONE DEEP DRAW. For the Speed Queen automatic washer, Vollrath craftsmen start with a circular blank of Republic ENDURO® Stainless Steel. Then, in a single operation, they deep-draw the blank into a tub in which diameter of the blank is reduced 50%. Proof of ENDURO's ductility and workability! Installed in the Speed Queen washer, the stainless tub adds sales appeal, promises lifetime service. Where can you use ENDURO to improve product or process? Republic metallurgical help is yours for the asking.

TWO-YEAR-OLD DRIVER TESTS NYLOK NUTS. They are used at several critical points of the Taylor Tot manufactured by The Frank F. Taylor Co., assuring positive locking even under severe shock, vibration and tension. Republic Nylok Nuts lock whether seated or not, protecting painted surfaces and soft metals. Positive locking assured wherever you stop wrenching. Even a two-year-old can't shake 'em loose. Want test samples? Write Republic, indicating size needed.

GET ZINC COATING PROTECTION WITHOUT COSTLY DIPPING AFTER FABRICATION. You can, with Republic Continuous Galvanized Steel. That tight, corrosion-resistant zinc coating will not crack, flake or peel under any forming process permitted by the base metal. Result is long-lasting protection without costly dipping. And, further finishing can be eliminated. Get the facts on this new production-line material, available in sheets and in rolls. Send coupon today.

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I'm interested in more information on:

- ☐ Republic ELECTRUNITE Mechanical Tubing
- ☐ Republic ENDURO Stainless Steel
- ☐ Republic Nylok Nuts
- ☐ Republic Continuous Galvanized Steel

Name_____ Title_____

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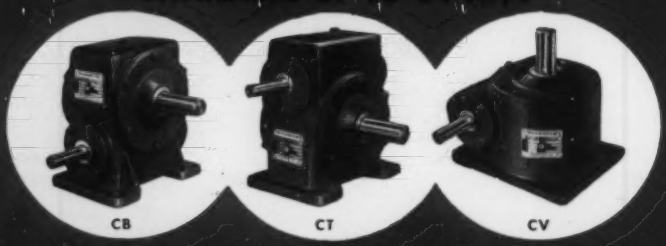
WINSMITH WORM GEAR REDUCERS
AVAILABLE UP TO 34 H.P.



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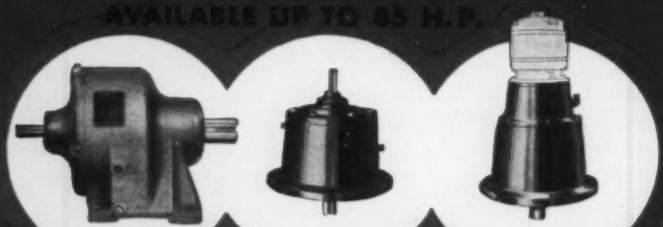

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THE ENGINEER'S Library

Recent Books

Physical Basis For Electrical Engineering. *By Thomas L. Martin Jr., head of electrical engineering department, University of Arizona;* 410 *pages, 6 by 8½ in., clothbound; published by Prentice-Hall Inc.,* 70 *Fifth Ave., New York* 11, *N. Y.; available from* MACHINE DESIGN, $10.00 *postpaid.*

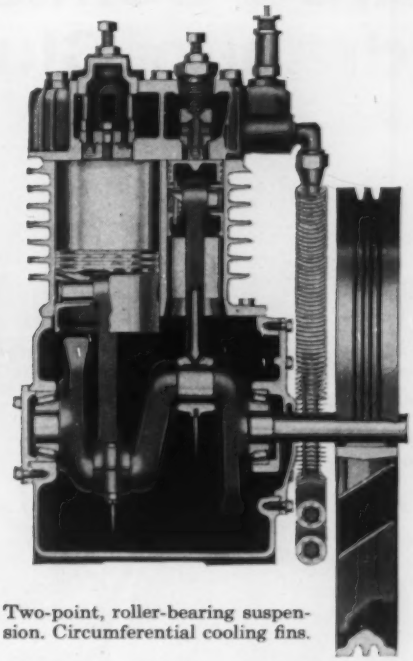
The material in this book is a simplified presentation of well-known phenomena and theories. Its main purpose is to show the broad physical basis supporting the phenomena associated with electrical engineering. Theory and concept are stressed. Little emphasis is placed on experimental or analytical methods.

High Pressure Technology. *By Edward W. Comings, professor of chemical engineering, Purdue University;* 572 *pages, 6½ by 9½ in., clothbound; published by McGraw-Hill Book Co. Inc.,* 330 *West* 42*nd St., New York, N. Y.; available from* MACHINE DESIGN, $11.50 *postpaid.*

This book covers the field of high-pressure technology. The central theme is the influence of elevated pressure on chemical and physical systems, and on equipment design for handling these systems experimentally or on a commercial scale.

After an introductory chapter, a number of chemical processes are listed and described to point out applications of other chapters. This is followed by an introduction to principles governing properties of metals, which provides a basis for selection and treatment of metals and alloys for high-pressure equipment. Included are procedures and suggestions for safety practices, principles of design of high-pressure equipment, stresses and strains in thick-walled cylinders, selected examples of apparatus and techniques used in measuring properties of matter at high pressures,

Model ACM vertical air-cooled compressor.



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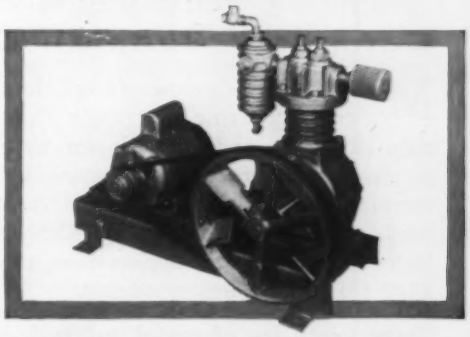

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Circle 576 on page 19

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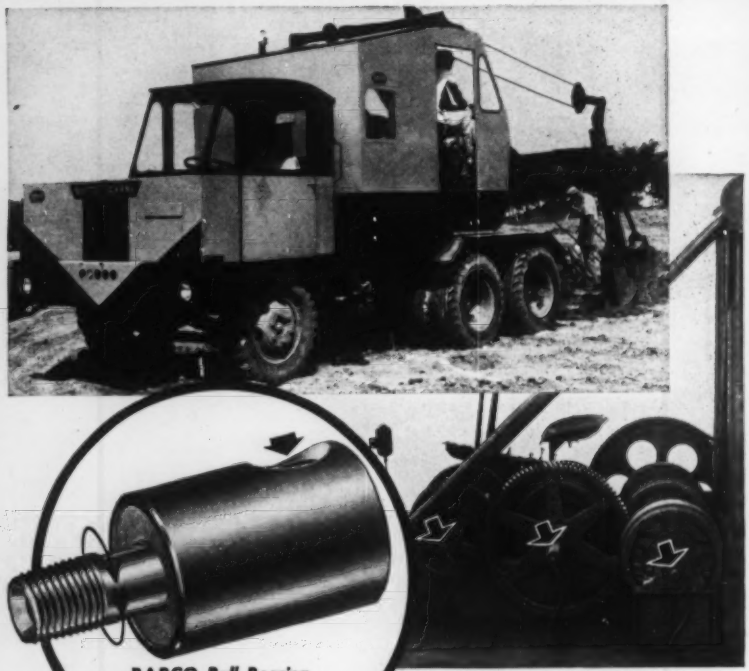

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SIZES:
¼" ⅜" ½" ¾"

Above—Efficient, smooth-working hydraulic operating control is one of the outstanding features of popular Thew-Lorain Moto-Crane, Model MC-107, power shovels and cranes. The arrows point to ¼" Barco ball bearing type single plane swivel joints used in the assembly.

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SEND FOR NEW BULLETIN 406A

gives details on Barco single plane swivel joints and their application to hydraulic and pneumatic service.

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and conducting chemical reactions.

The author is concerned with both theory and art of applying high pressure in the laboratory and in industrial processes. A glossary of unusual terms and words is included. The book provides a reference and text for engineers and scientists who undertake industrial or laboratory work at high pressure.

Rayleigh's Principle and Its Application to Engineering. *By G. Temple and W. G. Bickley, Imperial College of Science and Technology, London; 152 pages, 5½ by 8 in., paperbound; published by Dover Publications Inc., 920 Broadway, New York 10, N. Y.; $1.50 per copy.*

This book presents the theory and practice of the energy method for approximate determination of critical loads and speeds. Rayleigh's principle is applied for direct calculation of the approximate value of the fundamental period of a vibrating system or condition of stability of an elastic system. Presentation is accompanied by illustrative examples.

Transistors Handbook. *By W. D. Bevitt, Commercial Engineering Dept., CBS-Hytron; 410 pages, 6 by 8½ in., clothbound; published by Prentice-Hall Inc., 70 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$9.00 postpaid.*

Summed up for practical use is up-to-date information on transistors, their circuits, and their industrial applications. The beginning chapters present fundamental concepts, transistor types, characteristics, measurements, circuit properties and behavior. Later chapters discuss practical applications and methods of circuit analysis. Diagrams illustrate good practices in circuit design.

Pump Selection and Application. *By Tyler G. Hicks, Cooper Union School of Engineering; 422 pages, 6½ by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN; *$8.50 postpaid.*

This book covers the entire field of industrial pumping and is in-

Circle 577 on page 19

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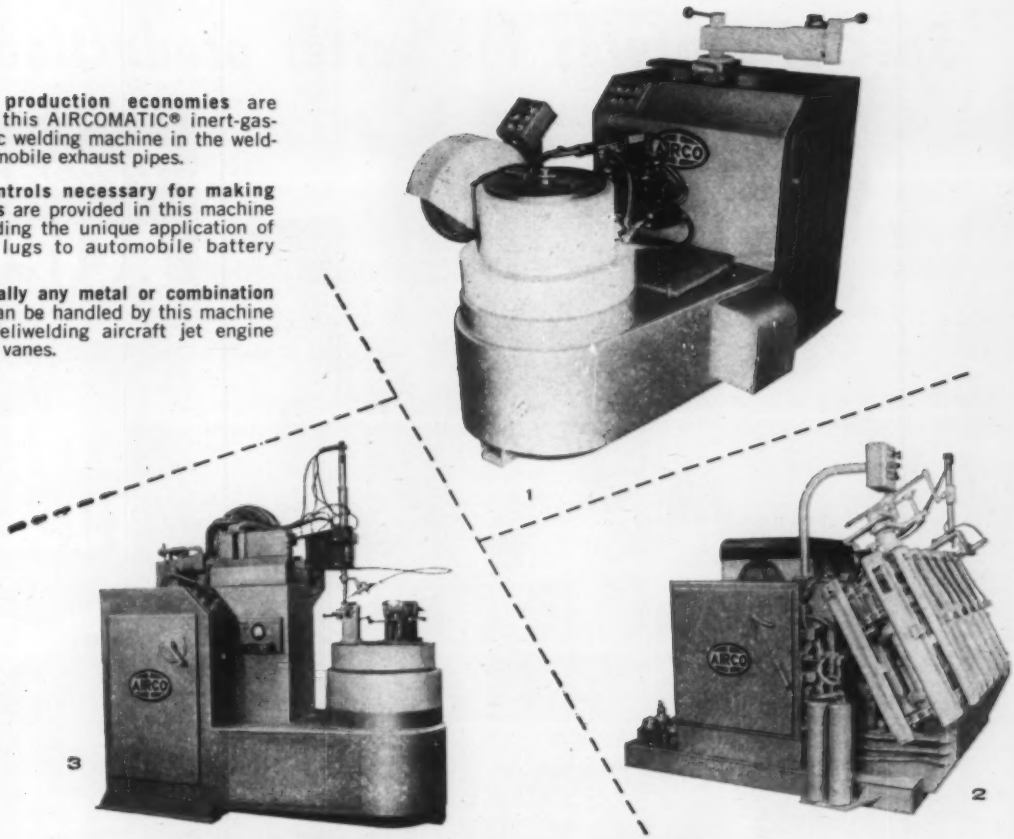

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New Cottrell five-color sheet-fed rotary letterpress for high speed production of fine quality boxboard printing. Photos courtesy of The Cottrell Company, Westerly, Rhode Island, a subsidiary of Harris-Seybold Company.

Cottrell rotary boxboard presses, built on the common impression principle, achieve remarkable color fidelity at speeds as high as 7000 sheets per hour. Available in 2, 3, 4, and 5-color models, they have many outstanding new features for better production.

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tended as a guide to help engineers select and apply pumps for all conditions. Step-by-step procedures are given for analyzing pumping problems. Illustrative examples are presented as guides.

Numerical Integration of Differential Equations. *By A. A. Bennett, W. E. Milne and H. Bateman;* 108 *pages,* 5½ *by* 8 *in., paperbound; published by Dover Publications Inc.,* 920 *Broadway, Dept. TF*1, *New York* 10, *N. Y.;* $1.35 *per copy.*

This is an unabridged republication of a monograph prepared for the National Research Council. New methods of integration of differential equations are described. Included are discussions on methods for partial differential equations, transition from difference equations to differential equations, and solution of differential equations to nonintegral values of a parameter.

Modern Mathematics for the Engineer. *Edited by E. F. Bechenbach, professor, University of California;* 514 *pages,* 6½ *by* 9½ *in., clothbound; published by McGraw-Hill Book Co. Inc.,* 330 *West* 42*nd St., New York* 36, *N. Y.; available from* MACHINE DESIGN, $7.50 *postpaid.*

A University of California Engineering Extension Series, this book contains a series of lectures presented by teaching scientists from a number of universities. It is intended to point out recent advancements in applied mathematical thought resulting from the development of analog devices and digital computers. Major divisions of the book are: mathematical models, probabilistic problems, and computational considerations.

Fundamentals of Sonar. *By J. Warren Horton, New London, Conn.;* 387 *pages,* 8½ *by* 11 *in., clothbound; published by the United States Naval Institute, Annapolis, Md.; available from* MACHINE DESIGN, $10.00 *postpaid.*

Written, for sonar engineers and naval officers concerned with underseas operations, this book sets forth the broad aspects of the manner in which sound is applied to the problem of underseas opera-

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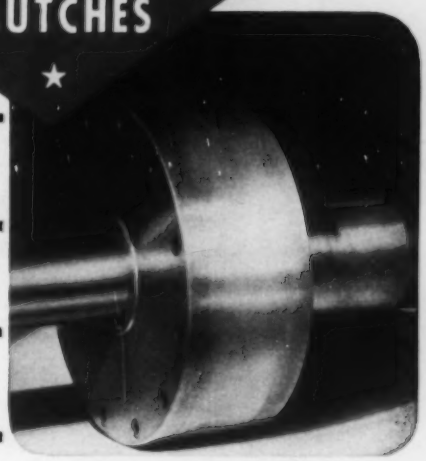

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Circle 580 on page 19

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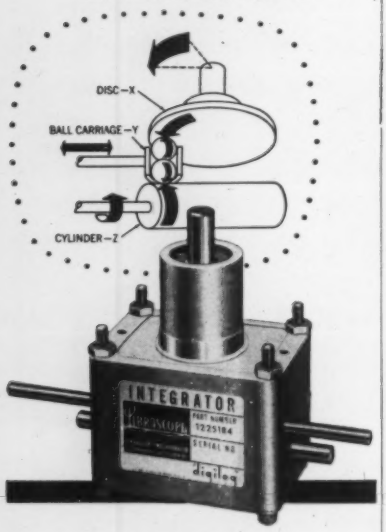

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tions. Technical material includes a review of elementary principles of acoustics, terminology and notations. Many formulas, a number of which have not been previously published, are also included.

The Icosahedron. *By Felix Klein; 289 pages, 5½ by 8 in., paperbound; published by Dover Publications Inc., 920 Broadway, New York 10, N. Y.; $1.85 per copy.*

This monograph covers the solution of quintics in terms of the rotations of regular icosahedron around the axes of their symmetry. It unifies previous knowledge on quintics and is intended for those interested in higher algebra, geometry, or the mathematics of crystallography. Contents include the theory of equations of the fifth degree and its historical development.

Association Publications

American Standard Terminal Markings for Electric Apparatus. *52 pages, 8 by 10½ in., paperbound; published by and available from American Standards Association Inc., 70 East 45th St., New York 17, N. Y.; $1.00 per copy.*

This standard for markings was developed to aid in making up connections to other parts of an electrical power system and to avoid improper connections which might result in unsatisfactory operation or damage. The standard covers power apparatus, generators, motors, transformers, feeder-voltage regulators, industrial controls, instrument transformers, current-limiting reactors and similar types of equipment.

A Glossary of Terms in Nuclear Science and Technology. *188 pages, 8½ by 5½ in., paperbound; published by and available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $5.00 per copy.*

This book contains glossary terms and definitions covering nine major topics peculiar to the field of nuclear energy. Included are new terms which have come into use recently, and terms that were before in a classified status. Major topics

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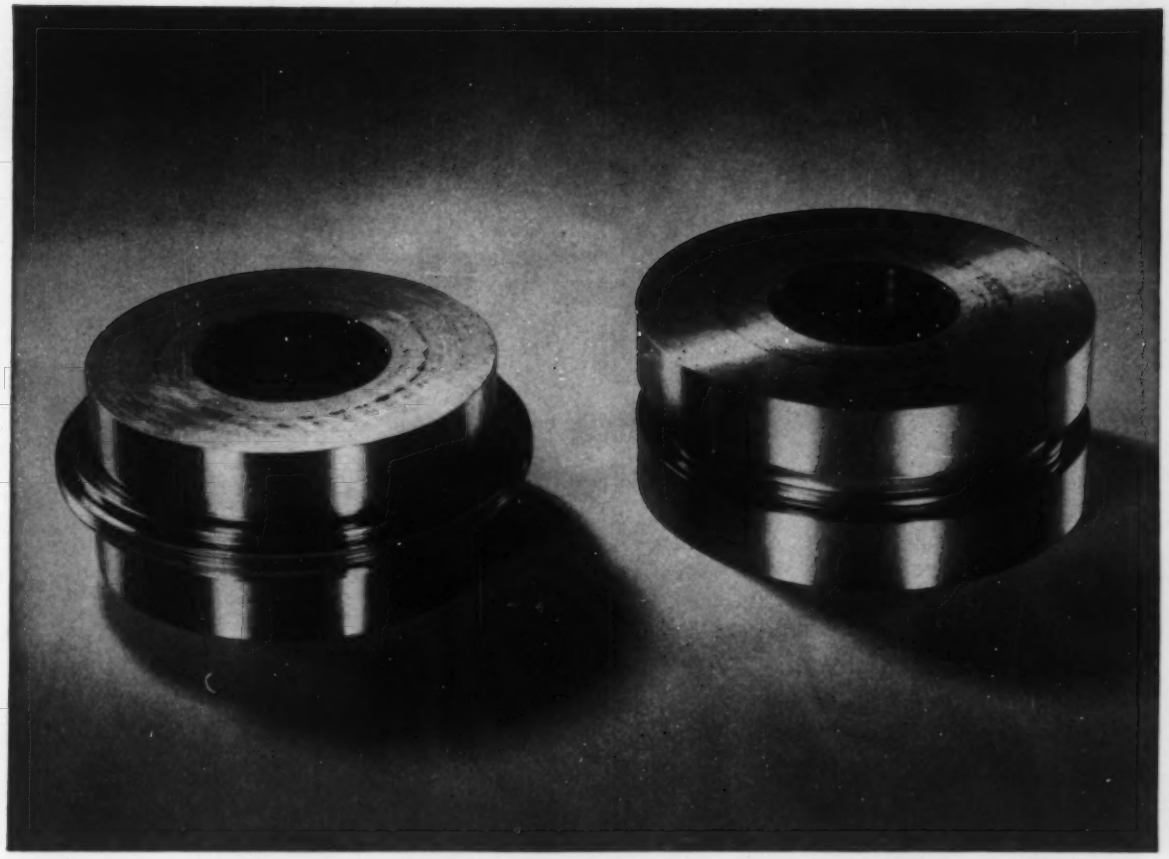

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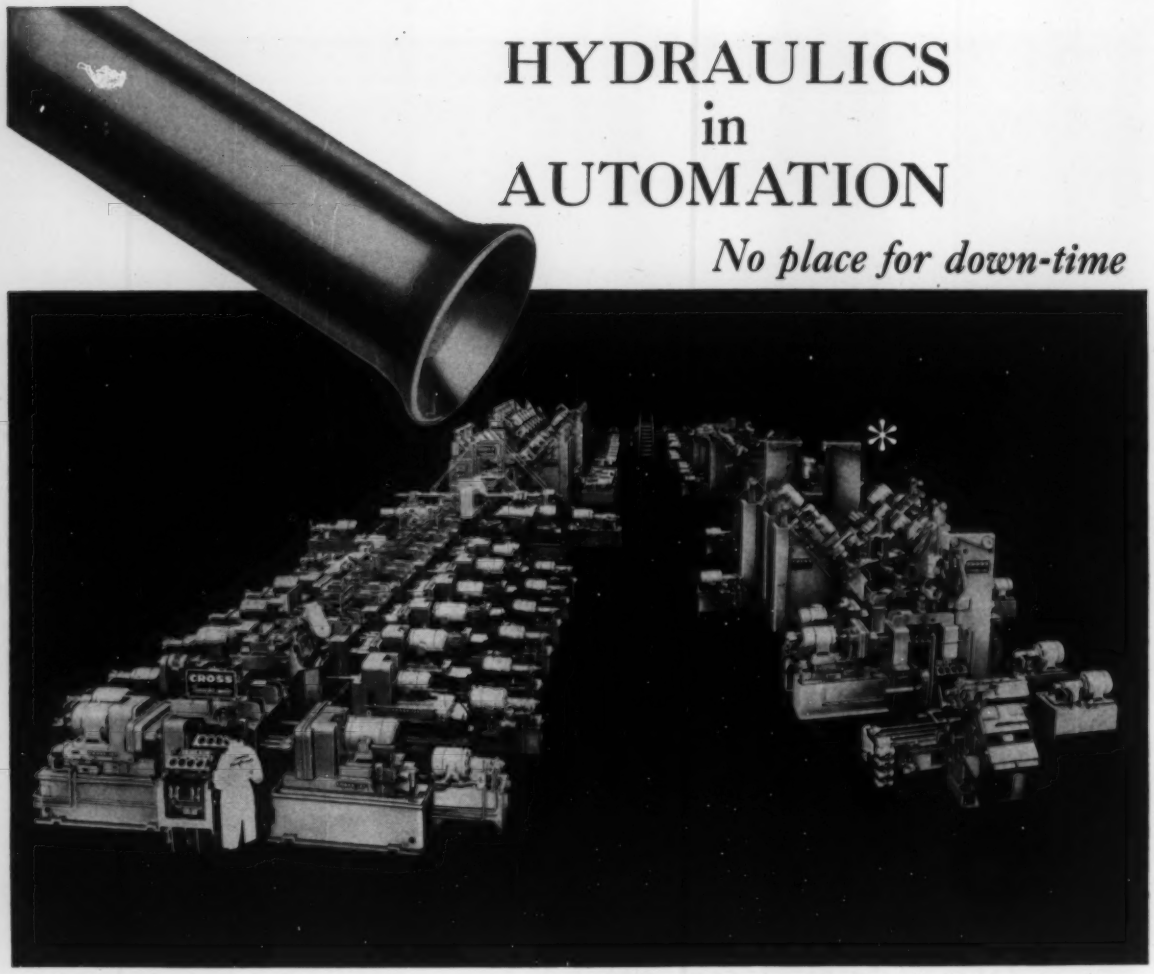

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Circle 584 on page 19

are: physics, reactor theory, reactor engineering, chemistry, chemical engineering, biophysics and radiobiology, instrumentation, isotopes separation and metallurgy.

Proceedings of the Second RETMA Conference on Reliable Electrical Connections. *103 pages, 8 by 10½ in., paperbound; published by and available from Engineering Publishers, Box 1151, New York 1, N. Y.;* $5.00 *per copy.*

This book is a practical manual for designing and producing reliable and economical connections. It covers techniques, tools, materials, methods, and testing. The materials discussed include soldered connections, solderless connections, brazed connections, ultrasonic joining, equipment and tools, fluxes, surface qualities, soldering to printed boards, solderable wire coatings, and reliability evaluation.

Government Publications

Fluids, Lubricants, Fuels and Related Materials. *By E. Erwin Klaus and Merrel R. Fenske, Pennsylvania State University; published in three volumes, each 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.*

This report describes work carried out on a continuing project to develop improved materials for the Air Force. The three volumes discuss investigations with lubricating oil, turbo-prop and turbo-jet lubricants, jet-engine lubricants, high-temperature hydraulic oils and jet fuel.

Part 1, PB 121508. 193 pages—$3.50 per copy.

Part 2, PB 121509. 220 pages—$4.00 per copy.

Part 3, PB 121510. 312 pages—$5.50 per copy.

NACA Technical Series. *Each publication is 8 by 10½ in., paperbound; copies available from National Advisory Committee for Aeronautics, 1924 F St., N.W., Washington 25, D.C.*

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Circle 585 on page 19

RONSON produces the First Electric Shaver with 2 Separate Cutting Heads

Ronson calls their new "66" Shaver "the most revolutionary electric shaver ever designed"—and offers strong evidence to support this claim. For one thing, it is the first electric shaver with an *extra* cutting head, called "Super Trim", which does every trimming job, from sideburns to mustache.

When any manufacturer is out to break precedent, and still sell his product at a competitive price, he needs every bit of designing and production skill he can find—anywhere.

Ronson found these in generous abundance at Mt. Vernon. Three of the vital parts of the "66"—the head frame and the plate covering the "Super Trim" blades (zinc castings), and the motor chassis (an aluminum casting)—were designed to obtain the special advantages of die casting: thin wall sections of great strength and rigidity, negligible machining, smooth finish, high speed production, low cost.

Says Ronson: "These parts are highly vital to our electric shaver. The cutting mechanism depends on the head frame for its accuracy of mounting and rigidity while cutting. The chassis on which the motor is built is of course the heart of the shaver's power system, and a very accurate casting is necessary for the job."

These advantages, important to any manufacturer, stem directly from the way we are organized here at Mt. Vernon. We have both the facilities and the complete die casting service it takes to produce parts like these, in any quantity, at minimum cost. We have 200,000 square feet of the most modern equipment for making dies and for die casting aluminum and zinc. And Mt. Vernon service comprises completely coordinated designing, die-making, casting, and machining, all under one roof.

It will pay you well to bring your production specifications to us. We may show you, as we did Ronson, the way to important cost reductions and improved products.

MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

SALES REPRESENTATIVES

Mr. Grant Eller
6 East 194th St., Cleveland, Ohio

Mr. Jerome J. Theobold
9 East Genesee St., Skaneateles, N. Y.

Mr. Arthur Diamond, Tools Incorporated
86 Bethlehem Pike, Philadelphia, Pa.

Mr. Anker Anderson
Cascade Road, Stamford, Connecticut

Mr. William Sauers
101 Briarcliff Road, Rochester, N. Y.

Mr. David H. King
75 Willow Street, Guilderland, N. Y.

Mr. George E. Hahl
39 South Munn Ave., East Orange, N. J.

Circle 586 on page 19

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Nuts — their use and abuse

With bolts tightened to high load levels, nut performance becomes critical.

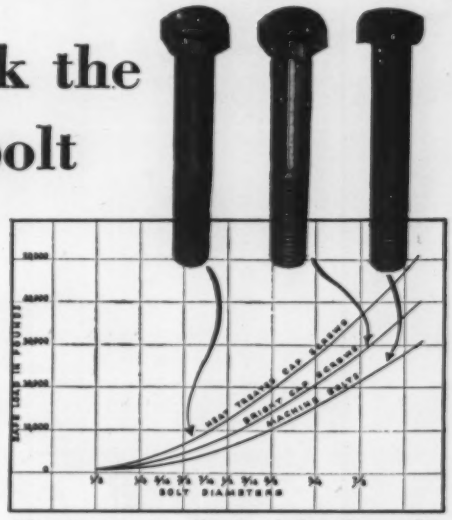
A nut produces bolt tension by rotating and advancing on the bolt threads. To do this, there must be a mating condition of threads, which is influenced by thread lead. Lead is a matter of tolerance only before bolt is stressed. When tightened, the nut is then under compression and threads tend to contract; the bolt is in tension, and threads tend to stretch. Lead of thread is affected—elastically *before* yield point, permanently *beyond* it.

This shortening of one lead and lengthening of the other has two effects. (1) The load distributes unequally along the threads (2) Torsion on bolt increases. Something has to give. For high tensile bolts especially, it is better for the nut to do so. A nut therefore should be soft enough so that it deforms plastically and compensates for off-lead. If it does, it *distributes* the load and can advance to increase tension.

"SOFT" NUTS DO MOST JOBS

"Soft" nuts do adjust more readily than hard ones under these severe conditions. While such nuts may not be as strong in shear as heat treated ones, the important point is the bolt tension they produce. As long as the nut can pull the bolt well into its plastic range, it is doing more than its share of the job.

How to pick the right size bolt



When it comes to uniformity of dimension, quality of head and thread, and ease of assembly, all RB&W cold headed fasteners are the same. They differ mainly in tensile strength as shown here.

ALMOST all bolt and cap screw strength requirements can be satisfied from three types of *standard* fasteners without recourse to costly special alloys. In the widely used middle range of sizes, the problem is one of deciding which makes the best joint, or which proves the most economical for the job.

MORE FOR LESS

Suppose, for example, you need a bolt safe for 20,000 pounds of loading. As the chart shows, you could use an RB&W 7/8" square-head bolt, a 3/4" bright cap screw, or a 5/8" heat treated one.

If you have a lot of holes to fill, use the larger, lower strength fasteners. But to cut down number of bolts, or their size (and therefore cost), go to the higher tensiles. However you gain nothing if you don't tighten high tensile bolts to their full strength.

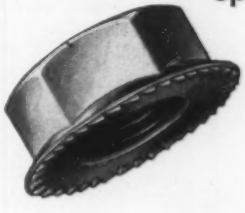
HOW COSTS COMPARE

In terms of holding power: For each $1.00 in high tensile bolts, it costs $1.50 to provide equivalent clamping force with bright cap screws; or $1.65 with machine bolts.

For more suggestions on fastener economy or for copy of above curves, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Spin-Lock Nuts dig in to stay tight



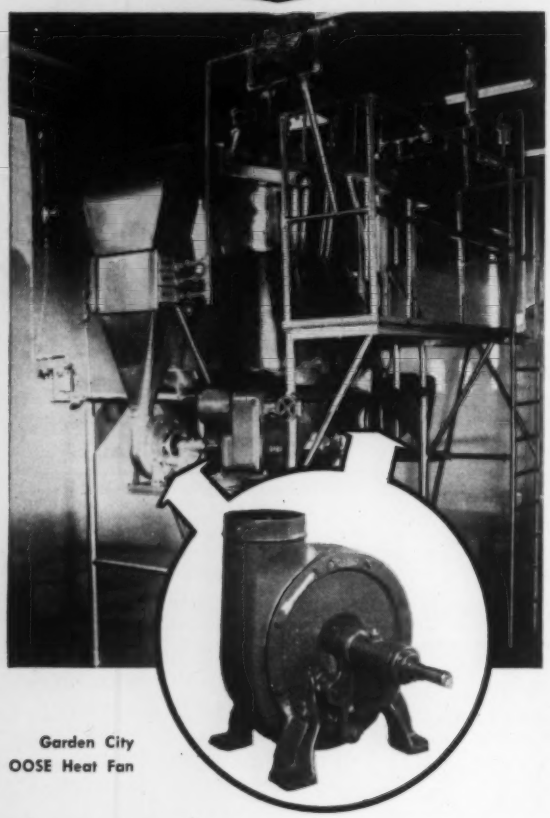
The photograph shows the many hardened "anchors" on the flange of a Spin-Lock Nut. These "ratchet-action" teeth require 20% more torque to loosen than to tighten. They bite in as the nut turns down on its seat. Like Spin-Lock Screws, these nuts can stay put in products subject to vibration and cyclic temperature variations. Send for bulletin.

Circle 587 on page 19

BLAW-KNOX* chooses

GARDEN CITY FANS

to change liquid milk into dry milk in their remarkable Instantizer!



Garden City OOSE Heat Fan

Fascinating—the way this fabulous Instantizer machine converts milk into powder form! First, the water is extracted . . . then the condensed milk-liquid is exposed to a current of hot, fast moving air (created by a Garden City OOSE heat fan) which effects immediate evaporation. Then another Garden City OOSE fan whisks away the milk powder in a conveyor.

You'll find Garden City fans in other blue-chip industries all over the nation. The advanced engineering features, remarkable efficiency level reported, and the low maintenance cost are among the many reasons why engineers are sold on Garden City.

**Dairy Equipment Division, Mora, Minnesota*

Write today for free booklet giving complete information.

GARDEN CITY FAN COMPANY
ESTABLISHED 1879

332 S. Michigan Ave.
Chicago 4, Illinois
Dept. G

Representatives in Principal Cities

• Fans for Industry • Backward Curve • Forward Curve
• Material Handling • Radial Bladed • Small Exhaust

Professional Viewpoints

. . . preferred thickness standard . . .

To the Editor:

It costs money to use the preferred thickness standard (ASA B32.1-1952 *Preferred Thicknesses for Uncoated Thin Flat Metals—Under* 0.250-*in.*). In cold dollars and cents it actually is expensive. Such a condition will ultimately defeat the purposes for which the standard was established, because basically industry must manufacture items for minimum cost. Any process, material, or standard which does not fit into this minimum-cost picture neither can nor will be adopted. Industry will benefit by the preferred thickness standard, but there is a flaw which must be remedied first so that its application can no longer be termed "expensive."

A specific example of this increased cost is found in an order recently forwarded to the purchasing agent of the Stanley Works for 50 tons of brass, strip, 0.050-in. thickness, for use in a new product. Upon investigation, the agent discovered that this thickness of brass, which was in accordance with the preferred thickness standard, would cost $10 per ton more than brass with a thickness of 0.0508-in.—a difference of only 0.0008-in.—and resulted in a cost differential of $500.

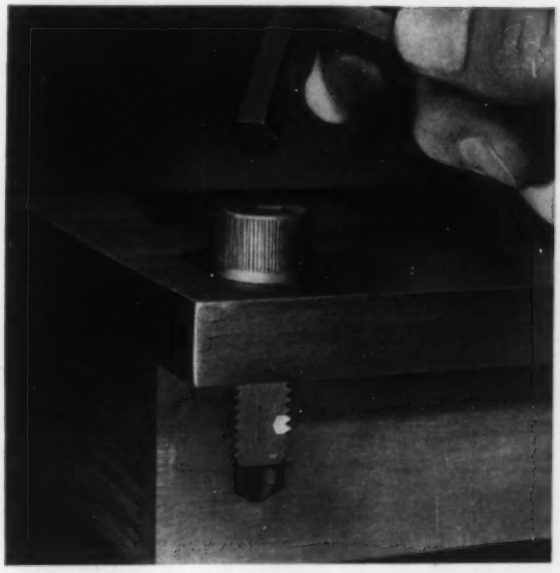
Examination of the accompanying table will illustrate many instances of such a price differential. Hot-rolled steel, thickness 0.063-in., costs $0.005 per pound more than hot-rolled steel, thickness 0.0636-in.—a difference of 0.0006-in. in thickness, but a difference of $500 for 50 tons. Cold-rolled steel, sheet, 0.028-in. thickness costs from $50 to $200 more for 50 tons

Price-Break Data

Pref. Thick. (in.)	Strip Break (in.)	Strip Diff. (in.)	Sheet Break (in.)	Sheet Diff. (in.)	Added Cost ($ per lb) Strip Min	Strip Max	Sheet Min	Sheet Max
			Hot-Rolled Steel					
.125	.127	.002	Same as strip		.0	.0035	No difference	
.080	.0822	.0022	Same as strip		.001	.007	.0	.0015
.063	.0636	.0006	Same as strip		.0005	.005	.0005	.0005
.056	.0568	.0008	Same as strip		.0005	.01	.0005	.001
.050	.0509	.0009	Same as strip		.0005	.017	No difference	
.028	.0284	.0004	Same as strip		.002	.015	No difference	
			Cold-Rolled Steel					
.100	.099	.001	Same as strip		.0015	.0035	No difference	
.028	.029	.001	.0284	.0004	.0005	.002	.0005	.004
.025	.026	.001	.0255	.0005	.0005	.0045	.0	.0025
.022	.023	.001	.0225	.0005	.001	.004	.0005	.002
.016	.017	.001	Same as strip		.0055	.01	.0	.001
.012	.013	.001	Same as strip		.0006	.0045	.0035	.0035
			Brass and Bronze					
.050	.0508	.0008	Same as strip		.005	.005	.005	.005
.025	.0253	.0003	Same as strip		.01	.02	.01	.02
.020	.0201	.0001	Same as strip		.01	.05	.01	.05
.012	.0126	.0006	Same as strip		.03	.08	.03	.08

The ordinary fasteners securing the worm wheel to the drum shaft in this automatic screw machine loosened, causing $120 worth of damage to parts. Labor for the repair job cost $100. The ordinary fasteners were replaced with self-locking UNBRAKOS, and there has been no trouble since.

Vibration won't loosen self-locking UNBRAKO socket cap screws



HOW IT LOCKS. The tough, resilient Nylok locking pellet keys itself into the mating threads. It forces threads together and locks the screw securely—whether or not the screw is seated.

UNBRAKO socket screws with the Nylok* self-locking device eliminate fastener problems caused by vibration.

Take the drive system in the automatic screw machine illustrated above, for example. The screws originally used to secure the worm wheel to the drum shaft loosened, causing considerable damage, besides loss of production time. These have now been replaced with self-locking UNBRAKO socket head cap screws and the trouble has been eliminated.

An UNBRAKO socket screw with the Nylok self-locking device is a single unit. Just screw it into any tapped hole. Seated or not, it locks positively wherever wrenching stops. Constant vibration or endless running of a machine won't affect these self-locking UNBRAKOS. The screws will not work loose!

Write today for your copy of Form 2193, which gives catalog and technical data on the complete line of UNBRAKO socket screws with the Nylok self-locking device. Or see your local industrial distributor. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

UNBRAKO SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

*T.M. Reg. U.S. Pat. Off., The Nylok Corporation

Circle 589 on page 19

NOISE *Bothers The Patient As Well As The Drilling*

Scott Sound Level Meter Aids The S. S. White Dental Mfg. Company To Produce a Quieter Dental Instrument

The Noise of modern high-speed dental equipment can be very annoying to patients. White's engineers use the Scott 410-C Sound Level Meter in production testing of their new ball-bearing hand piece to insure that the noise of finished instruments does not exceed the standard set for them.

Completely Portable Sound Level Meter Helps YOU Design A Quieter Product

A quiet product gives you an important sales advantage. H. H. Scott's sound Level Meter, and Sound Analyzer can help you locate, measure and minimize noise and vibration. Here are important features of the Scott Sound Level Meter and Sound Analyzer.

- Sound Level Meter is flash-light size weighing only 2 lb. 7 oz. Sound analyzer is only 10" x 10" x 6".
- Extreme portability and battery power of these instruments makes them easy to set up and use in field measurements.
- Both instruments meet all applicable standards of the American Standards Association.
- Sound Analyzer has Passband adjustable in half octaves for more precise measurements.
- Sound Level Meter received the Electrical Manufacturing Award for outstanding design.

Fill out coupon! Learn how the Scott Sound Meter and Analyzer can help you

h. h. Scott

H. H. Scott — Dept. MD-6
385 Putnam Avenue
Cambridge, Massachusetts

Send me complete information on Scott Sound Level Meters and Analyzers and your FREE booklet "NOISE SIMPLIFIED."

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Professional Viewpoints

than cold-rolled steel, sheet, 0.0284-in. thickness, although the difference in thickness is only 0.0004-in. Brass, strip, 0.012-in. thick, costs from $60 to $80 per ton more than 0.0126-in. thick brass, strip.

The extra cost is due to the fact that price-break points (the points at which the cost increases because of the additional rolling of the metal) are not based on the preferred thickness standard. Anyone familiar with the old gage designations will recognize the fact that these price-break points are based upon that system.

It can be seen from the chart that the price-break points are not standard in the metal industry. They vary both between different metals and between different forms of the same metal.

When it is necessary to eliminate excessive material costs, it is also mandatory that deviations from the preferred thickness standard occur under existing conditions. When this deviation is required on nearly 25 per cent of the standard thicknesses, it then means that we deviate more than we adhere to the standard. It also means that many of the acknowledged benefits from use of the preferred thickness standard are lost.

It is acknowledged that use of the standard does allow reduction of the number of thicknesses of materials to be stocked, it does eliminate the gage number bug-a-boo, and it does facilitate the interchangeability of metals in designs. It is also true, however, that unless the added benefit of a favorable cost differential can be assured, the standard cannot attain maximum usefulness, nor will the parallel financial benefits to all users exist.

Therefore, it would seem desirable for standards engineering groups, purchasing agents groups, design engineers groups, and management groups to sponsor a program to bring the pricing system and the preferred thickness standard into concord.

—GEORGE E. GILPATRICK
The Stanley Works
New Britain, Conn.

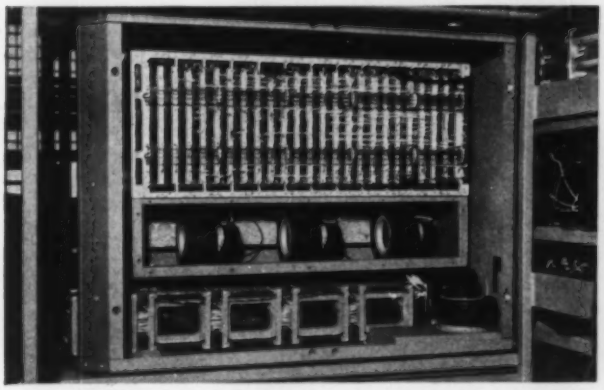
Tips and Techniques

Pencil-Sharpener Aid

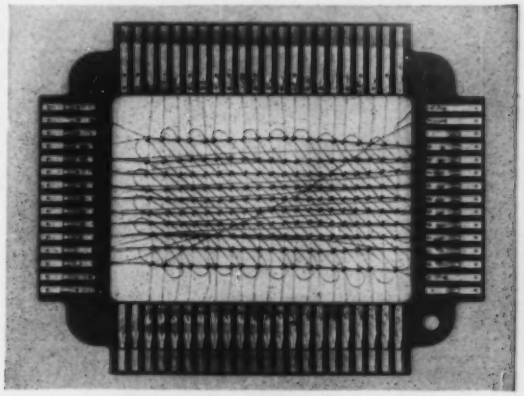
A sanding pad for pencil sharpening can be rigged so that it is readily available for easy use, yet is neither on the table surface nor hanging where it will soil the draftsman's clothing. Two screweyes are fastened to the bottom surface of the drafting board. A cord is fastened to the sandpaper paddle at the end opposite the handle. The cord runs through the screweyes and a weight is fastened to the end. A piece of cheesecloth or tissue, stapled to the back of the paddle, is convenient for wiping the sharpened lead. — S. B. SPRAGUE, *Deltec Inc., Youngstown, O.*

THE NATIONAL SCENE

KEEPING "ELECTRONIC BRAINS" FROM LOSS OF MEMORY. One of science's greater marvels is IBM's 705 Electronic Data Processing Machine—which makes intricate calculations and logical decisions in millionths of a second. Heart of this electronic "wizard" is its main magnetic core memory. Designed for use with the machine's high-speed printer is the IBM 760 Control and Storage Unit containing its own core memory of 1,000 positions which allows central processing to continue in the 705 while other data are being printed. Helping the 760 remember what information is to be printed is a job for PHENOLITE® Laminated Plastic. PHENOLITE's unique combination of properties makes it ideal for this application.



MOST ADVANCED FORM OF ELECTRONIC STORAGE. The 1,000-position core memory for the IBM 760 Control and Storage Unit—a portion of which is shown here—consists of pinhead size cores strung on copper-wired frames of PHENOLITE. Electrical impulses, passing through wires, alter the magnetic state of cores so that a group of them stands for a word or figure. Reversing the process recalls information from storage. PHENOLITE frames safeguard the circuit and permit stacking of core planes as shown.



PHENOLITE MEETS CRITICAL STANDARDS. Core frames like the one shown are punched out of laminated PHENOLITE by IBM. Each frame has printed circuit type terminal strips and soldered connections. PHENOLITE proves an ideal material for this application because it is mechanically strong and stiff, punches cleanly, etches well, remains flat, has high dielectric properties and withstands the heat of dip soldering.

NATIONAL CAN HELP YOU reduce unit product cost or improve product performance at no added cost. Here's why . . . You can select the "one best material" from over 100 grades of PHENOLITE, Vulcanized Fibre and National Nylon—without compromise in properties or cost. You can simplify production and purchasing with the timed delivery of 100% usable parts—from a single reliable source. You gain competitively with National's new materials and grades—the direct result of programmed materials-research.

You benefit by calling National first. Check Sweet's PD File 2b/Na, the Telephone Directory Yellow Pages, or write Wilmington 99, Delaware. Dept. G6.

NATIONAL
VULCANIZED FIBRE CO
WILMINGTON 99, DELAWARE
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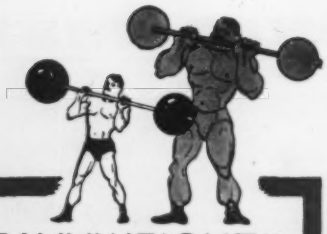
NATIONAL FIBRE CO. OF CANADA, LTD., Toronto 3, Ont.

Circle 591 on page 19



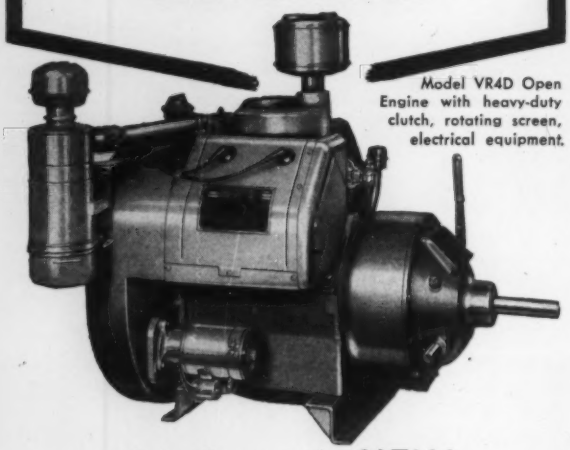
here's "HEAVYWEIGHT" power performance

in a light weight, man-size

WISCONSIN

Air-Cooled

ENGINE



Model VR4D Open Engine with heavy-duty clutch, rotating screen, electrical equipment.

Introducing the NEW

56 HP. Model VR4D

• Climaxing years of engineering development, this great new engine offers manufacturers and users of power equipment all the advantages of AIR-COOLING, at temperatures from low sub-zero to 140° F., in an exceptionally rugged engine that measures up to any "heavyweight" industrial type liquid-cooled engine, horsepower for horsepower, with many *plus values.*

The outstanding High Torque characteristic of the Model VR4D engine, combined with its extremely rugged construction and heavy-duty stamina, provide *load-lugging holding power,* long life and top power performance.

Advanced "V" design provides an extremely compact power package which includes all traditional Wisconsin heavy-duty features such as tapered roller main bearings plus additional new features.

This new engine rounds out a complete line, comprising 15 models in 4-cycle single cylinder, 2- and 4-cylinder sizes, from 3 to 56 hp. Write for "Spec" Bulletin S-207.

WISCONSIN MOTOR CORPORATION

MILWAUKEE 46, WISCONSIN, U. S. A.

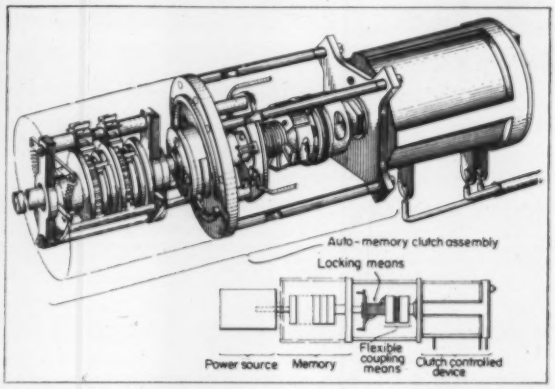
World's Largest Builders of Heavy-Duty Air-Cooled Engines

NOTEWORTHY

Patents

Memory Clutch

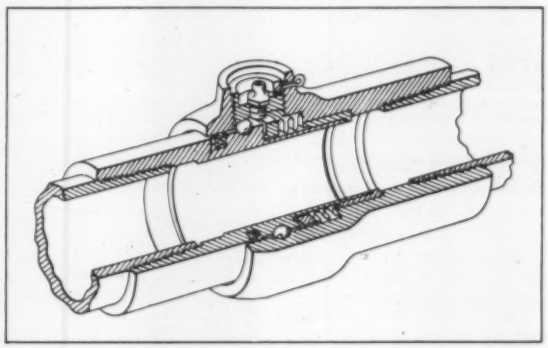
Extension of the mechanically-limited rotational range of a multiturn potentiometer—while retaining "memory" of input turns beyond the stop position—is a function of an automatic memory clutch. Shown here coupling a motor (inset, left) to a 10-turn po-



tentiometer (right), the clutch first releases the potentiometer shaft when the stop position is reached in either direction, and then counts and memorizes input turns beyond the 10-turn limit. When the direction of rotation of the input shaft reverses, the memory clutch reproduces the stored turns in the required direction and picks up the potentiometer shaft at the point where it was previously released. Other applications include storing or memorizing rotational analog information in control systems. *Patent* 2,788,-667 *assigned to Northrop Aviation Inc. by Adam Krauszer.*

Swivel Joint

Effective at high temperatures and pressures, a compact swivel joint permits limited relative angular and rotational movement between coupled fluid-carrying pipes and tubing. Design incorporates an anti-



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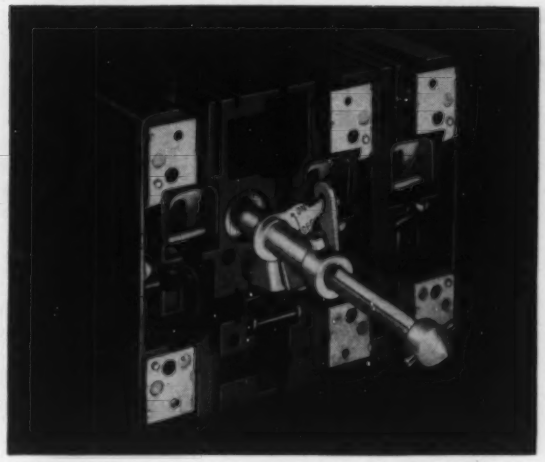

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NEW

Westinghouse VISI-FLEX De-ion Switch fits any panel

• ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE • ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE •

This compact new type of panel switch features . . .

- Visible contacts
- Fused or unfused operation
- Choice of Vari-depth or toggle handle
- Standard cover drilling
- Fast mounting
- Low cost

Quick-make, quick-break action plus De-ion arc-quenching grids assures positive switching, long operating life. Ready visibility of the blades means extra safety.

The Vari-depth operator, featuring a threaded telescoping shaft, makes it easy to fit panels of various depths . . . without mounting stilts. It also simplifies cover drilling.

Fuse kits permit mounting several sizes of fuse clips on the switch. As a fused switch, Visi-Flex saves space and the cost of separate fuse blocks.

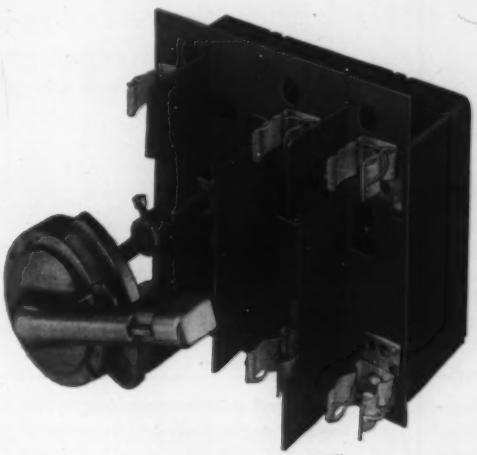
For use as a disconnect switch, a safety shield without fuse clips is available. You just order the basic switch and the required kit . . . all hardware is included.

Low in cost, flexible, simple to install, Visi-Flex requires a mininum of space. Visi-Flex switches come in 30- and 60-ampere ratings. 100- to 200-ampere models available later.

For additional information write to Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa., for Booklet SM-5457.

J-30276

Model A has adjustable Vari-depth handle mechanism—shown with fuse kit assembled. Also available with safety shield for no-fuze operation.



Model T has toggle handle for slide plate or cam-type mechanism—shown with a safety shield for no-fuze operation. Also available with several sizes of fuse clips.

YOU CAN BE SURE...IF IT'S

Westinghouse

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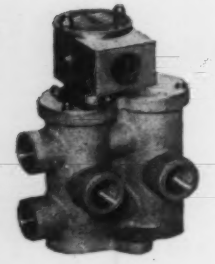
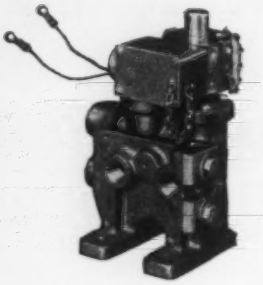
Crescent® Solenoid Valves

COMPETE ON PRICE

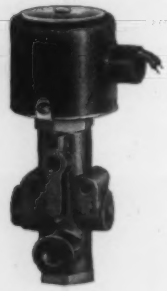
BUT LEAD IN SERVICE LIFE



Standard 4-Way



J.I.C. Type 4-Way



Standard 3-Way

® 4-Way and 3-Way Solenoid operated, pilot controlled valves for Air, Water and light oil to 150 P.S.I., products of Crescent Valve Co.

NO COIL BURNOUT

because a generous power margin, short solenoid travel and pilot operation combine to prevent overheating and overloading. Note that these valves are accepted and used in automotive plants where assembly line production does not permit coil or valve failure.

LONG SERVICE LIFE

Main valve design is aimed at extremely long trouble free service. Resilient seats are tight sealing and are not affected or damaged by dirt or grit because they are of a self scavenging design. Witness their superior performance in such severe service as operating hopper doors on cement batching equipment and in other dusty environment.

INTERCHANGEABILITY

Solenoids and pilot sections are interchangeable from one valve size to another, minimizing spare parts requirements. Adaptation to any practical voltage is achieved by a simple coil change.

Speed of response, speed of installation and dependable leakproof operation year in and year out are responsible for the increasing switch to Crescent valves on production machinery where time is money.

For complete data write for Catalog 6-C.

BARKSDALE VALVES

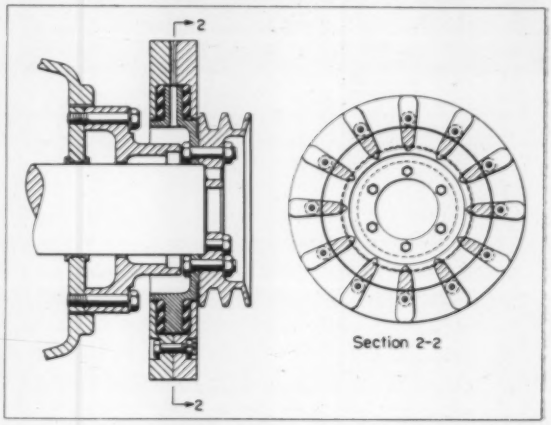
5125 Alcoa Avenue, Los Angeles 58, California

Noteworthy Patents

friction bearing, a face seal—loaded axially by a metallic bellows—and a lubrication fitting. Because radial and axial joint dimensions are small, the unit is particularly suited for limited-space application. Introducing negligible pressure drop, the joint accommodates axial movement of the connected tubing without leakage. *Patent* 2,789,843 *assigned to Chiksan Co. by Peter J. Bily.*

Torsional Vibration Damper

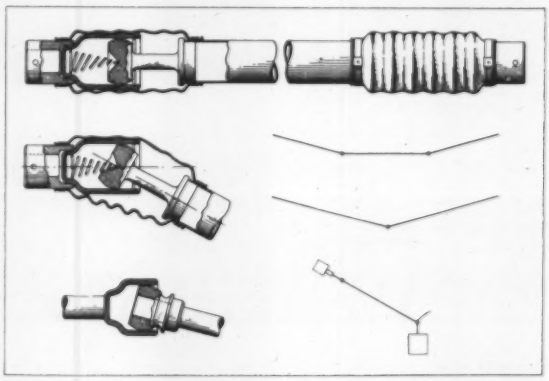
Rubber disks provide frictional coupling between the driving member and the floating inertia ring in a torsional vibration damper. Circumferentially

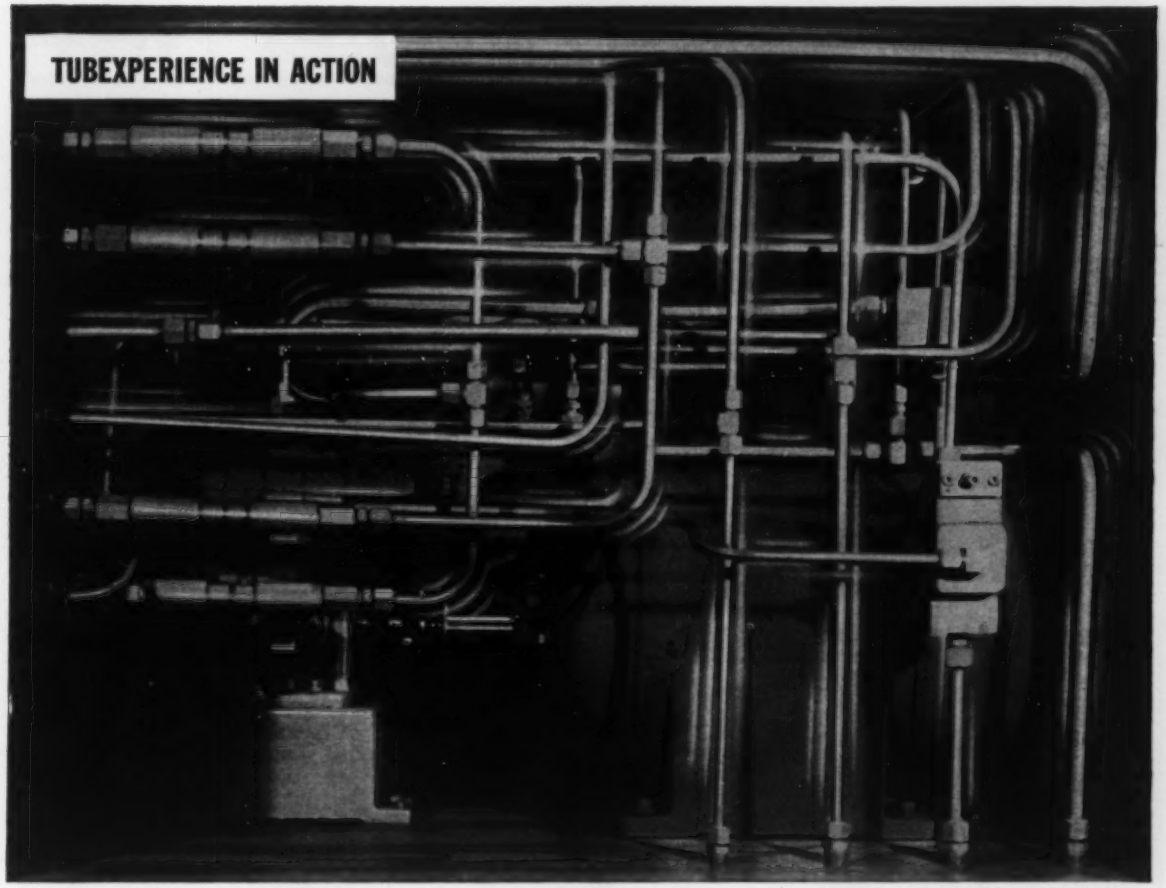


spaced slots in the driving web—shown here bolted to the drive pulley—provide cooling air flow to the friction disks, preventing deterioration of the disk rubber during operation of the damper. *Patent* 2,779,210 *assigned to Murphy Diesel Co. by John H. Holloway.*

Constant-Velocity Universal Joint

Shaft angularities ranging as high as 45 deg are accommodated by a ball-socket type universal joint that incorporates only one socket and one knuckle. Constant velocity ratio between driving and driven elements is provided by the contacting conjugate surface of the knuckle. Design eliminates need for





VIBRATION can murder hydraulic lines

Only tubing with high ductility and smooth, uniform surfaces can take this terrific punishment in its stride!

When big motors start delivering power, hydraulic lines go into their vibrating dance. Unless the lines are made from highly ductile material and have exceptionally smooth, uniform surfaces, the ceaseless, pounding vibration may actually cause cracks and ruptures.

Superior hydraulic tubing is available through leading warehouse distributors from coast to coast. Contact the one nearest you today for information—or get a free copy of Bulletin 39 by writing to Superior Tube Company, 2008 Germantown Ave., Norristown, Pa.

HERE'S WHY SUPERIOR (SAE) HYDRAULIC TUBING WILL GIVE YOU LONGER, MORE ECONOMICAL SERVICE

High ductility! *Furnished in dead-soft annealed temper, Superior hydraulic tubing flares easily, bends without pinching, can be readily fabricated for any hydraulic application.*

Non-aging steel! *All Superior hydraulic tubing is made of selected non-aging steel. It keeps its ductility, will not become brittle with age. Carbon content is limited to .12% maximum.*

Bright, smooth, clean! *Special processing gives Superior hydraulic tubing an unusually bright, smooth, clean finish on both OD and ID; reduces turbulence and pressure drop. Shipped with special rust preventive coating on both inside and outside surfaces.*

Fully tested! *And not mere random sample testing! Every length of Superior (SAE) hydraulic tubing is 100% hydrostatically tested at maximum working pressure—giving you realistic performance insurance.*

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ¼ in. OD—certain analyses in light walls up to 2½ in. OD

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Here is a simply operated, cost-saving lettering machine ideal for lettering on specification sheets, bills of material, instruction manuals, and forms, etc. Type fonts are available with engineering and mathematical symbols.

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Company Name.....
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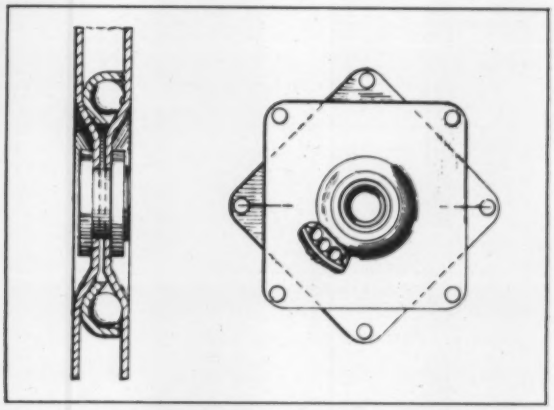
Noteworthy Patents

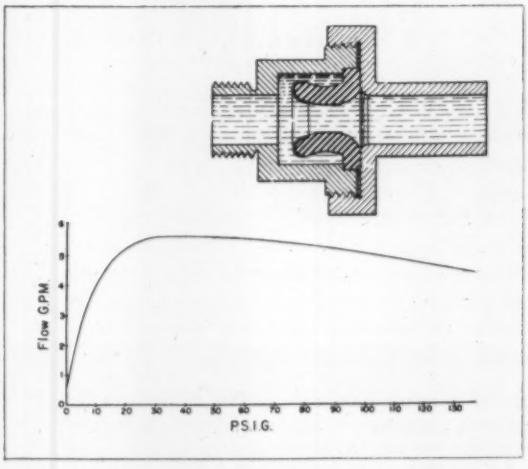
splined shaft connections adjacent to the joint. Other advantages of the joint, which is economical enough for use in simple agricultural machinery, include: high load capacity in proportion to size, large grease capacity, durability and simplicity of manufacture. *Patent* 2,780,080 *assigned to Process Gear and Machine Co. by Gordon H. Cork.*

Swivel



Design of a ball-bearing swivel allows it to turn freely when a relatively light axial force is applied but blocks further spin when force is removed. Use is for supporting TV cabinets, revolving tables, chairs, etc. Swivel comprises sheet-metal attaching plates, separated by ball-race and bearings. *Patent* 2,779,642 *assigned to Wil-Mat Corp. by John T. Matthews.*

Flow Control Device



Throttling action of a flexible venturi-shaped element holds flow through a fluid-flow control device substantially constant despite changes in inlet pressure. Contraction and expansion of the venturi, which corrects flow rate to design value, is caused by the pressure difference between the stationary fluid on the venturi outside surface and the fluid passing through its throat. *Patent* 2,781,058 *assigned to General Electric Co. by John D. Warhaus.*

THIS IS GLASS

a bulletin of practical new ideas *from Corning*

New, neat way to heat

You can't buy this heater, *yet*. It's new—in fact so new in concept that what you see is a preliminary design sketch.

What makes it so unusual is the heating element it is designed around. Corning's *new* tubular heating element called HEAT SHEATH®.

This is what the basic unit looks like.

Essential components are: VYCOR brand glass tubing, colored *red;* capped leads; and a completely enclosed, extremely efficient wire heating element.

True . . . sheathed heating units are not new. But HEAT SHEATH offers a *combination* of important advantages to you who seek a compact, efficient, versatile source of heat.

Let's start with the glass tubing. It's made of a VYCOR brand glass that contains 96% silica. And silica in such amounts gives this glass the ability to cope with the usually adverse effects of both *high temperatures* and sudden *thermal shock*.

For example: You can take an object made of a VYCOR brand glass, heat it to 900° C., and then plunge it into ice water *without* cracking, crazing, shattering, or any change in form.

Next, consider the freedom of design this tubing offers . . . and how little space it requires. (O.D. is ⅝".) With a tentative rating of 500 watts per linear foot, you can provide desired heat with short sections "banked," or long, single units.

These units heat up fast, too, going from room temperature to maximum rating within 5 seconds. The warm red coloring is right in the glass—it can't wear out or off. (Note: Specific shade depends on wattage input and varies from a deep red to a cheerful ruby glow—colors that add *psychological* value to the heat.)

Naturally, the glass enclosure protects the heating element from dirt, dust, and accidental shorting. Fire hazard is reduced to zero. And the heating element itself has a life rating of 5,000 hours, *plus*.

Not interested in portable heaters at the moment? How about laundry dryers, broiling units, baseboard heating, air conditioning, industrial dryers? Maybe you've already thought of other possible applications.

If you're interested in finding out more about this compact, attractive, versatile, and challenging item, contact our Appliance Parts Sales Department. Write, wire, or phone.

Afterthought: There are 7 different glasses in the VYCOR brand group. We have a booklet that tells about them, gives details on thermal characteristics, radiant energy control applications, and such. The booklet is Bulletin B-91. Free with the coupon.

On the level

This intriguing (though difficult to show to advantage) bit of gadgetry is part of a *turn-and-bank* indicator for airplanes.

We don't make such instruments. We do supply the glass tubing, made from one of our PYREX brand glasses.

Those who do fashion instruments of this type find Corning a reliable, economical source for this tubing. Besides being free from visual defects this tubing is rugged, accurate and easily worked.

Astute makers of many things have discovered the practical and profitable road to glass components. They bring their wants to Corning.

The list of items and special glasses involved almost defies enumeration. (There are some 65,000 glass compositions in our files.) But a good start is a pleasant book called "This is Glass." Free. And/or drop us a line briefing your problem and we'll investigate and report promptly.

How to prevent TV sunburn

Those who perform in front of TV cameras are occasionally subjected to an occupational hazard called "television sunburn."

Cause of this unsought skin tinting is the intense heat generated by the big lights used to illuminate sets.

Now set the stage for another problem: Telecasting during the *summer* from a barn-like structure that has defied every effort of those versed in the art of air conditioning.

This "*double trouble*" is what the producers of a popular show, called "Grand Ole Opry," faced last summer. Putting the show on from Ryman Auditorium in Nashville, Tennessee, loomed as quite an ordeal.

Enter here a sensitive and knowledgeable person. His suggestion: Try PYREX brand infrared reflecting glass.

Sheets of this glass were placed in front of the lights with simple brackets. Here's what the setup looked like:

Heat output was reduced some 50%. Yet this PYREX brand infrared reflecting glass still transmitted 75% of the wanted light.

Conclusion: Where there's a knotty problem you'll often find a Corning glass to solve it. A number of good examples are detailed in Bulletin PE-34, a concise reference on infrared, sight glasses, flat glasses and sundry other useful items. A check in the coupon brings it to you.

Corning means research in Glass

CORNING GLASS WORKS, 52-6 Crystal Street, Corning, N. Y.

Please send me the following material: Bulletin B-91, "VYCOR brand Industrial Glassware by Corning" ☐; Bulletin PE-34, "Corning Flat Glasses" ☐; Illustrated booklet, "This is Glass" ☐.

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Circle 597 on page 19

MOTIONS-IN-MINIATURE
CLUTCHES BY FORMSPRAG

ACTUAL SIZE

Now! The modern sprag principle comes to small over-running clutches

Formsprag—pioneer in the development of sprag-type clutches—now offers a truly versatile small clutch for hundreds of varied applications.

In terms of your product's performance, Formsprag FS-02 and FS-04 clutches provide unusual compactness, utmost accuracy and torque, simple and dependable operation. And they are easily adapted to a large variety of mounting arrangements.

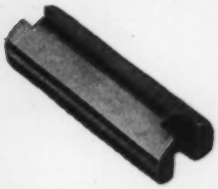
Manufacturers of automatic coil-winders, stamping machines, laundry machines, table band saws, etc. are already utilizing these versatile clutches. Why not profit by their experience?

HERE'S REAL COMPACTNESS

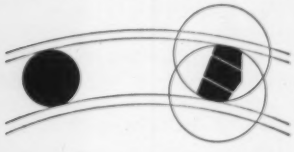
	Bore Size	O.D.	Torque	Over-running Speed
Model FS-02	¼"	1¼"	50 in. lbs.	*2400
Model FS-04	⅜" and ½"	1⅝"	200 in. lbs.	*2400

*Higher speeds possible on special applications. Consult with factory.

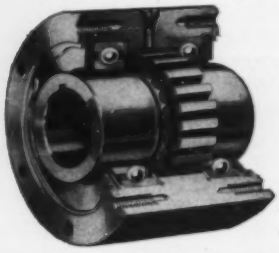
WHY IT PAYS TO DESIGN "THE FORMSPRAG PRINCIPLE" INTO YOUR PRODUCT



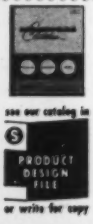
Sprags are an advanced design of precision wedges made of hardened alloy steel. Utilized in a clutch, they increase the efficiency and prolong the life of all equipment using an over-running clutch or ratchet.



The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space—therefore, of increased torque capacity.



Basic construction of the Formsprag Clutch is simple. A full complement of sprags is inserted between inner and outer concentric races. Contact with both race surfaces is maintained by energizing springs.



MORE INFORMATION?

Should you require details on these Formsprag small clutches as well as the complete line, write today for this new 26-page catalog.

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications

FORMSPRAG COMPANY

23603 HOOVER ROAD, VAN DYKE (DETROIT), MICH.

World's largest exclusive manufacturer of over-running clutches

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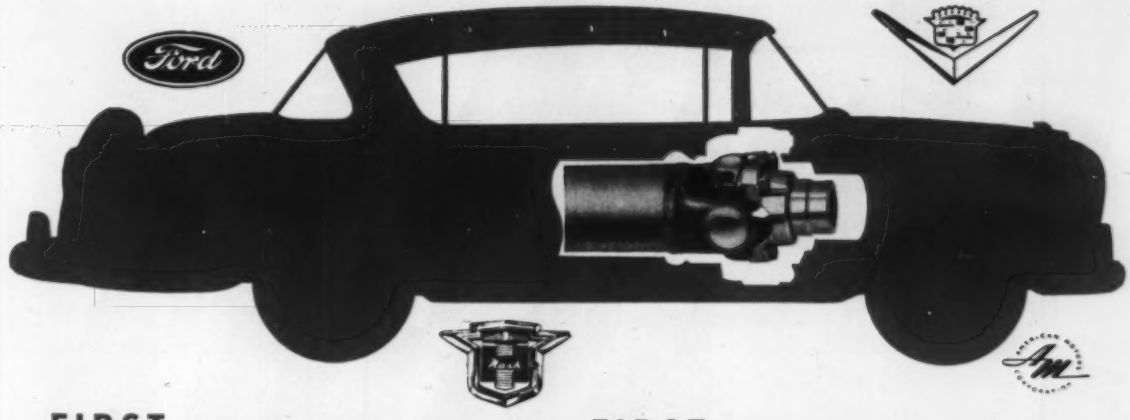
FIRST



FIRST to make an Automobile Joint smaller —(3-9/16" swing diameter) to reduce the clearance needed by the low floor boards in modern cars.

FIRST to make the smaller joints stronger —(2500 lbs. ft. torque) to meet the needs of higher speed, higher power modern cars.

FIRST to make the smaller, stronger joints lighter—(20% less than other joints having the same torque capacity) to help designers keep overall weight down to modern standards.

FIRST to make the smaller, stronger, lighter joints easier to install—(less parts to handle) to save time and money on the assembly line.

Send a print and specifications of your new model for MECHANICS engineers' recommendations how you can give your next car the benefit of these four competitive advantages—provided by the new MECHANICS joint development.

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Export Sales: Borg-Warner International
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UNIVERSAL JOINTS

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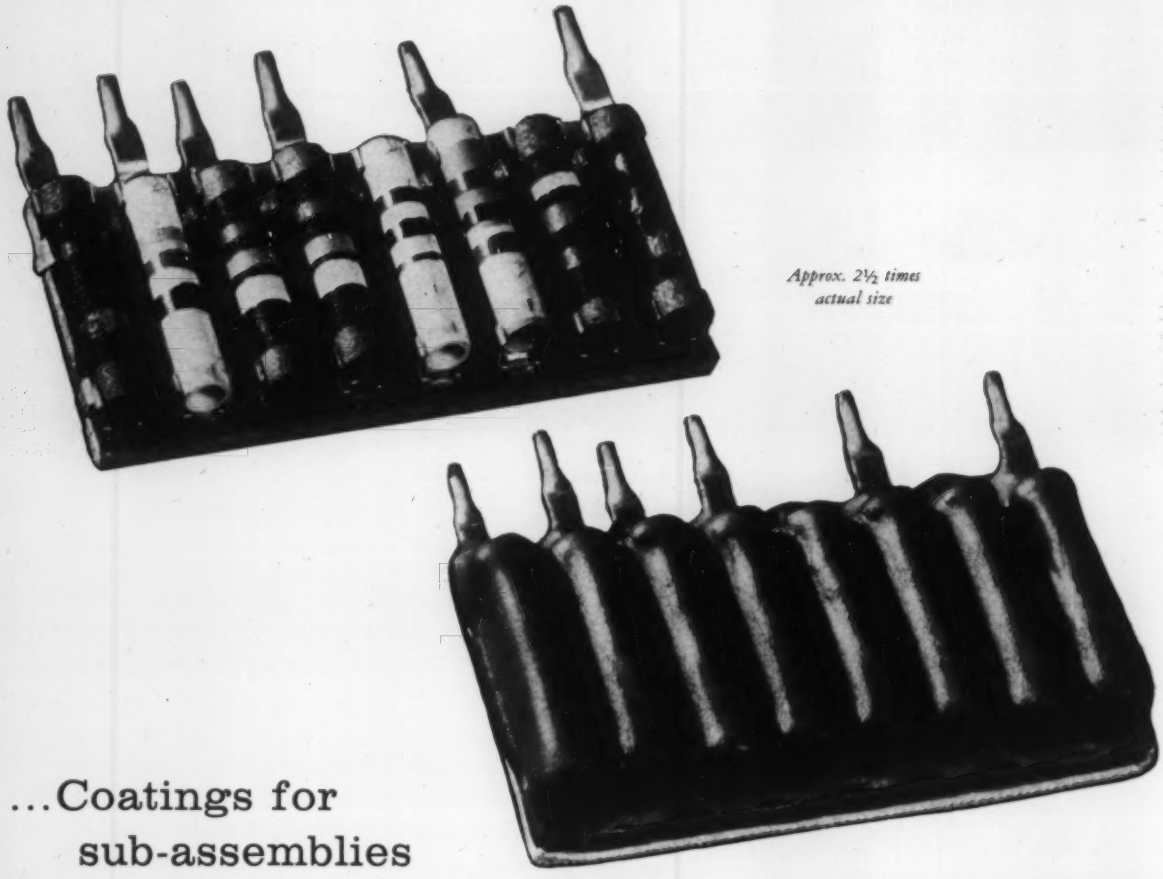
Circle 599 on page 19

wrapping up a problem in electronics



Approx. 2½ times actual size

...Coatings for sub-assemblies suggest **other** jobs for **DUREZ** phenolic **RESINS**

IF YOU ARE FACED with a situation requiring exceptional properties in a bonding, impregnating, or coating agent, consider what Erie Resistor Corp. accomplished when it turned to Durez resins for its Pre-Assembled Components.

DEVELOPED TO EFFECT major cost reductions for electronic equipment manufacturers, these Erie "PAC" circuits combine capacitors and resistors in unitized packages for quick installation in a printed circuit board. Complete flexibility of design is offered in modules combining up to 90 components in one "package."

INSULATING PROPERTIES, mechanical strength, and heat resistance of Durez thermosetting phenolic are key factors in the protective dip-coating applied to "PAC" units. With Durez, Erie meets its own requirements that no migration or peel-back of insulating material occur when a soldering gun is applied. In the dip compound the resin produces a material that is free from running or sagging. The slight porosity of Durez allows Erie's protective wax coating to penetrate to a depth that insures complete insulation, and it cures to a hardness that permits stamping or color coding.

Can the remarkable properties of Durez thermosetting phenolic resins solve a problem for you? Whether thermal, electrical, or mechanical characteristics come first in the application you may have in mind, why not look into Durez now? Feel free to call on our long experience with these materials.

DUREZ®

Phenolic Plastics that Fit the Job

DUREZ PLASTICS DIVISION

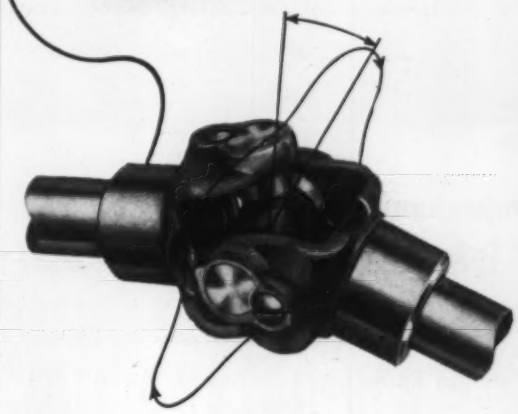
HOOKER ELECTROCHEMICAL COMPANY

506 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

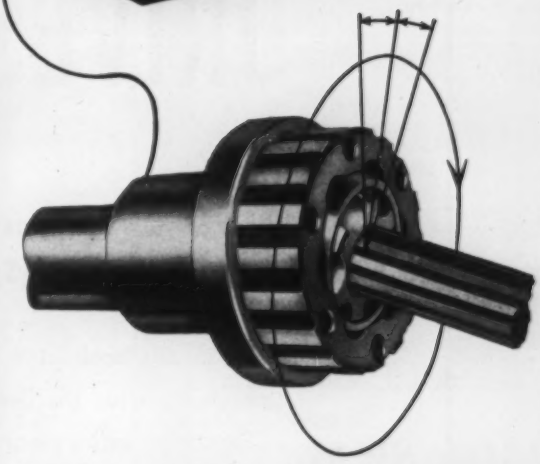
Circle 600 on page 19

THIS ACTION MAY HAVE A
LOWER PRICE



Old-fashioned pin or slipper-type joints speed up, slow down twice during one revolution. This delivers rough "rock and roll" torque which results in greater vibration and wear. They must employ clumsy additional mechanisms to compensate for their unbalanced action at extreme angles.*

THIS ACTION ALWAYS HAS A
LOWER COST



Rzeppa Joints *always* transmit smooth "full power" torque at angles as much as 35°! Ball bearings—located in a plane bisecting the angle between driving and driven members—deliver smooth rotation, eliminating wear and vibration. Constant velocity means longer joint and shaft life, too.*

57A

RZEPPA
SHEPPA

CONSTANT VELOCITY UNIVERSAL JOINTS

The Gear Grinding Machine Company
3937 CHRISTOPHER, DETROIT 11, MICHIGAN
MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES
DETROIT SCREWMATIC 750 SINGLE SPINDLE SCREW MACHINES

*HOW RZEPPA'S CONSTANT VELOCITY SAVES YOU MONEY. If a universal joint operates with less friction it wears longer; if it has a higher capacity it can produce more. Through the principle of constant velocity—shown above—Rzeppa delivers these cost-savings that are impossible with designs of lower price.

Send us a dimensional sketch along with peak horsepower, operating angles and R.P.Ms. Our engineers will assist in making a proper joint recommendation. WRITE FOR LATEST BROCHURE.

NOW in one book

. . . what the designer should know about . . .

ADJUSTABLE-SPEED DRIVES

. . . covers all the basic methods of adjustable speed!

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". . . the most comprehensive design guide on Adjustable-Speed Drives available *anywhere*"

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Here, in *one* book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed. It contains the entire co-ordinated program of articles which appeared in MACHINE DESIGN on main drive and transmission types—electric-motor, slip-coupling methods, mechanical drives, and hydraulic drives.

You will find basic analyses of types and selection factors, useful listings of nomenclature and symbols, charts on control systems, tradename listings, and many other practical design details.

A *must* for your "working library". Use the handy form below and order your copies today! (Remittance enclosed with your order will speed the delivery of your copies.)

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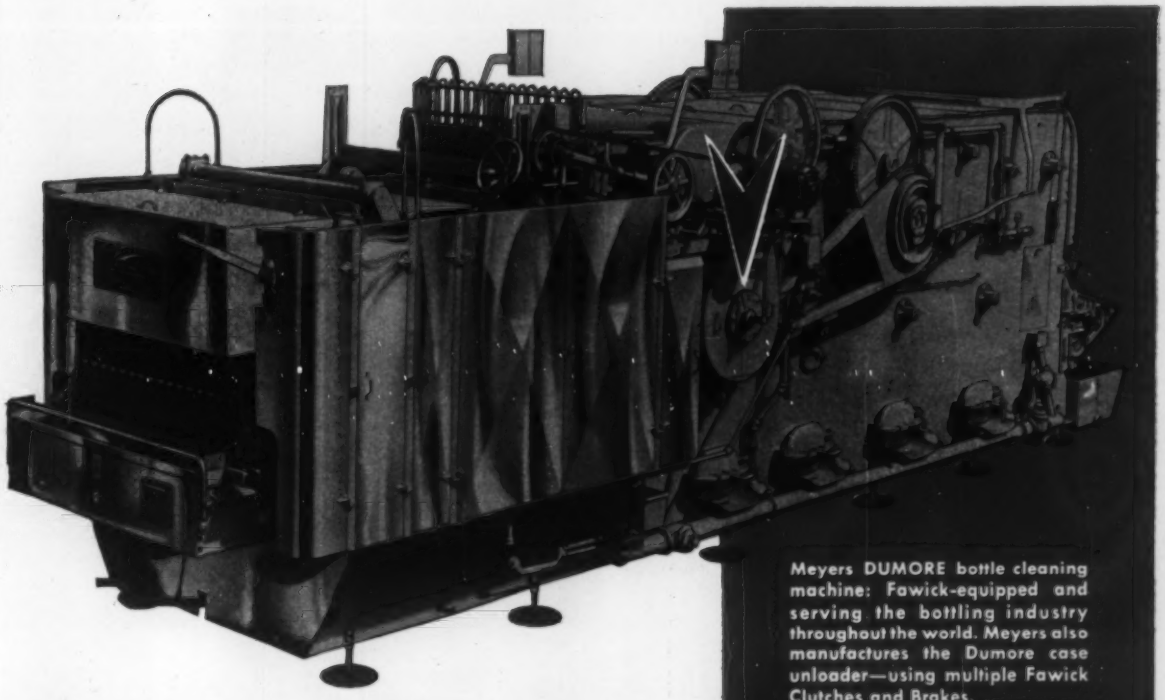

Meyers DUMORE bottle cleaning machine: Fawick-equipped and serving the bottling industry throughout the world. Meyers also manufactures the Dumore case unloader—using multiple Fawick Clutches and Brakes.

this world-wide supplier of bottling equipment reports—

"our customers *specify* Fawick Airflex Clutches"

CB Airflex Clutch: For high speed cyclic or continuous operation . . . needs no lubrication . . . adjusts automatically for wear of friction shoes.

" Fawick . . . has eliminated many years of difficulties experienced with mechanical clutches. "

" . . . now we have no adjustments for proper operation . . . bulky and troublesome linkages are eliminated."

" . . . our customers are specifying that our new machinery be equipped with Fawick Airflex Clutches."

—George J. Meyer Manufacturing Co., Cudahy, Wisc. Largest firm in the world devoted exclusively to manufacture of bottling equipment.

Airflex Clutches and Brakes are eliminating maintenance—providing increased production, greater safety and fast, fingertip control on *every type* of power equipment.

Discover the important, profit-boosting reasons for FAWICK leadership in *making power behave.*

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
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In Canada: Fawick Canada Ltd., Toronto

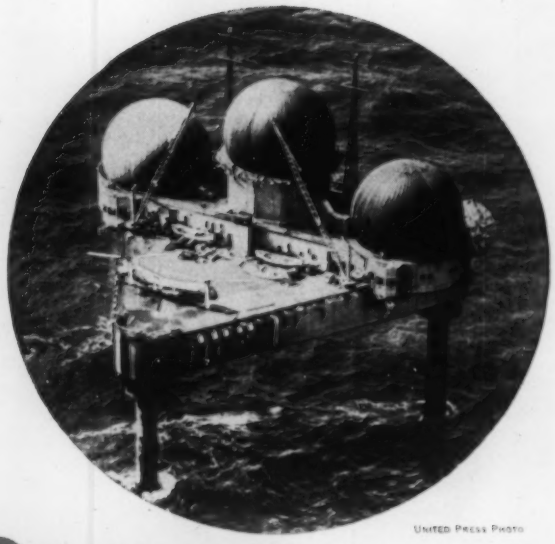
Performance is Proof . . . Fawick Is Best

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

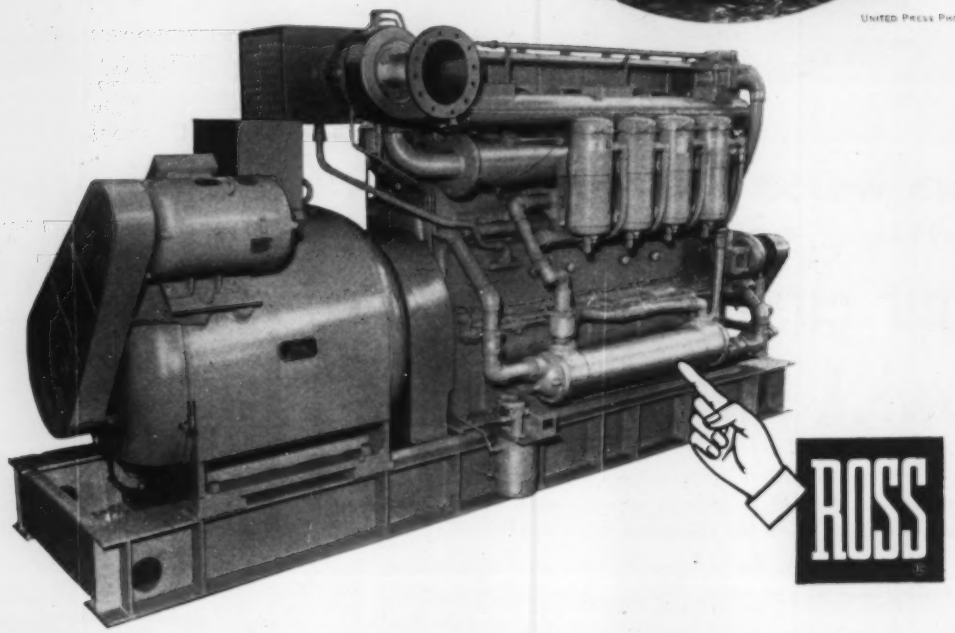
Circle 602 on page 19

ROSS EXCHANGERS

stand guard over Superior Generator Sets aboard "Texas Tower"



UNITED PRESS PHOTO



110 Miles off the coast of Cape Cod stands this U. S. Air Force radar picket station called the Texas Tower. Around the clock its radar eyes search the skies, ready to give our coastal defenses advance warning of approaching enemy aircraft.

Selected to generate additional power required for vital radar operations, two White 250 KW Superior Diesel Generator Sets must give dependable performance over long periods. To insure this, Ross Type BCF Exchangers maintain safe lube oil temperatures. Excessive heat is dissipated and vital parts receive an ample supply of properly cooled oil at all times.

Ruggedly built and top-rated for thermal efficiency, Ross Exchangers safeguard numerous types and makes of prime equipment at work on the toughest jobs—where engines are often called upon to operate continuously over extended periods.

Completely pre-engineered, these compact units are fully standardized in sizes to meet a wide variety of oil, water, gas and air cooling requirements.

Learn what Ross Exchangers can do for you by requesting Bulletin 1.1K5. Write: Ross Heat Exchanger Division of American-Standard, Buffalo 5, N. Y. In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

ROSS HEAT EXCHANGER

Division of AMERICAN-Standard

NOSCO "CAN DO"

takes mammoth projects in stride

Take the case of Gould-National Batteries, Inc. After personal inspection of many plastic molding plants, evaluating engineering personnel and facilities, Gould selected Nosco to produce a new line of ten stationary battery containers and their covers. Nosco "Can Do" started by assigning an experienced sales-engineer to supervise and coordinate the program and report progress to Gould every two weeks. Twenty molds were completed in little more time than is usually required to produce one . . . from drawing board through chrome plating. Nosco molded the containers of acrylonitrile, running several molds simultaneously on giant pre-plasticized presses. The molded pieces were annealed a truckload at a time, and decorated by an ingenious method which avoided duplication of screens. Finally, these parts received comprehensive approval by Western Electric inspectors.

The Gould-National contract is one more indication of the scope of Nosco "Can Do". More than service, engineering, and production know-how, Nosco "Can Do" includes the financial ability to carry large tooling and warehousing programs.

When awarding your large plastic parts program, call on Nosco "Can Do".

The first step is to write—

For other case histories—and for a glimpse of the Nosco plant and facilities, send for the free 12-page brochure, "How the Nosco Plant Works to Produce Your Needs in Practical Plastics."

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World's largest injection molding plant

again available in reprint • • • •

"MECHANISMS FOR INTERMITTENT MOTION"

by Otto Lichtwitz

A SYSTEMATIC TREATMENT OF THE PROBLEMS INVOLVED FOR IMPARTING INTERMITTENT MOTION THROUGH EXTERNAL AND INTERNAL GENEVA AND STAR WHEELS, AND INTERMITTENT MECHANISMS FOR INTERSECTING AND CROSSING SHAFTS

In the December 1951, and January, February and March 1952 Issues, MACHINE DESIGN published what has proved to be an enormously successful series of articles on "Mechanisms for Intermittent Motion". Mr. Lichtwitz' approach to the subject of intermittent motion is systematic and extremely well organized. The tables provided to reduce time and effort in making detailed calculations are themselves invaluable.

We have re-reprinted a supply of booklets of this series because requests for copies have been constant ever since it was first offered . . . our initial supply ran out many months ago.

A worthy addition to your "working library" . . . use the handy form below and order your copies today! (Remittance enclosed with your order will speed the delivery of your copies.)

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DU PONT ELASTOMERS

neoprene · Hypalon

in design

"Non-skid" neoprene reels help dye slippery synthetic fabrics

Gaskets of HYPALON unaffected by 2% ozone after two years' use

For two years, a large chemical firm has used gaskets of HYPALON in its ozone generators. Despite constant exposure to 2% ozone, not one gasket failed because of ozone cracking.

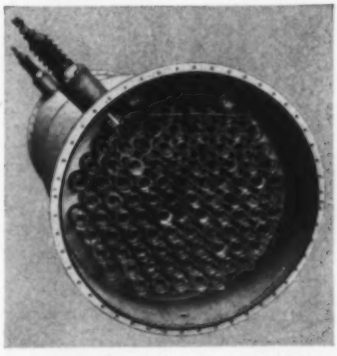
The ozonator is a steel shell packed with glass tubes. As dry oxygen passes through the tubes, it is converted to ozone by high-voltage electrical discharge. Each end of the shell is closed by a dished head sealed with a gasket of HYPALON.

Plastic gaskets too rigid

Plastic gaskets, which were formerly used in the generators, were unaffected by ozone, but took a permanent set under flange pressure. When a head was removed for routine maintenance the plastic gasket was too distorted to put back. Gaskets of HYPALON are reused.

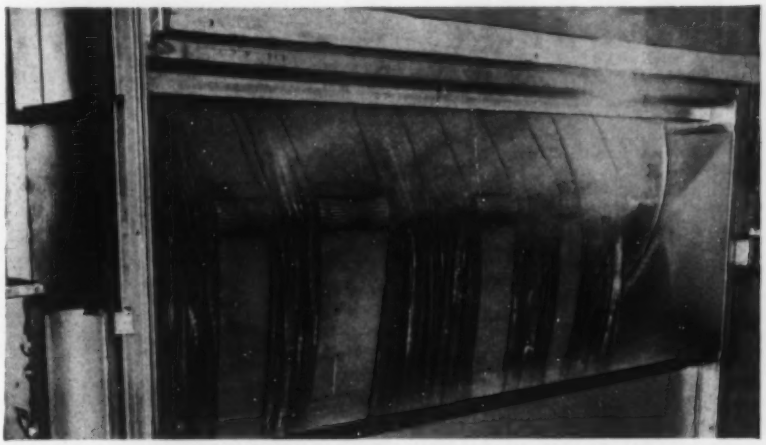
Designing with HYPALON

HYPALON offers many additional advantages compared to other types of rubber. It resists strong oxidizing acids; can operate at temperatures from 250° F. to 350° F.; resists weather and sunlight. This Du Pont synthetic rubber can also be compounded in an unlimited range of stable colors. HYPALON offers extra long life and lower operating costs in jobs where conditions are severe. Just mail coupon for full information.



Gaskets made of HYPALON seal each end of this ozonator; they show no deterioration after two years in service.

Circle 605 on page 19



Fluted neoprene bars show little wear after four years in dye machine. Dye bath may be acid or alkaline, oxidizing or reducing. Temperature is 200° F.

Mill uses neoprene to get needed traction for hauling fabric through dye bath

Chatham Manufacturing Co., of Elkin, N. C., used neoprene to solve an unusual problem in dyeing synthetic fibers. Long loops of the fabrics are dyed in stainless steel piece dyeing machines. Loops, often 100′ long, are pulled through the dye bath by means of a reel. The slow rotation of the reel assures even dyeing over the full length of the goods.

The progress of the fabric depends entirely on friction between reel and loop. When several types of metal reels failed to produce enough friction to pull the smooth synthetic fabrics through the bath, Chatham designed special fluted neoprene bars for the reels. They provided adequate traction and ended the problem of slippage and uneven dyeing.

Chemical resistance important

Bars covered with natural rubber could have solved the traction problem but neoprene was chosen for its excellent chemical resistance. In dyeing various fabrics the dye bath may be acid or alkaline, oxidizing or reducing. Each dyeing cycle requires 3-5 hours at 200° F., and the dye machines operate 24 hours a day. Ordinary rubber just couldn't stand this treatment. Chatham's Superintendent of Dyeing, Mr. V. Caton, reports that neoprene has given excellent service for four years with little wear.

Neoprene's resistance to chemicals, heat and abrasion means long-term wear—and economy in many types of service. Mail coupon below for full details on how neoprene can work for you.

DU PONT
REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc).*

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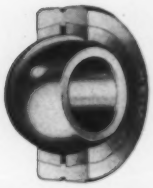
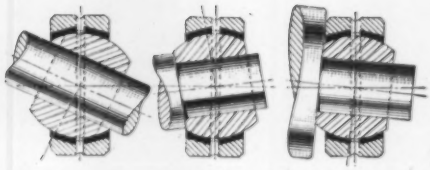
HEIM BEARING



Cutaway Shows Housing— Bronze Inserts— Hardened, Ground Ball



Maximum angle of misalignment

HEIM *Unibal* BEARINGS

Correct misalignment in every direction.

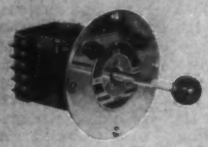
Carry heavier axial and thrust loads.

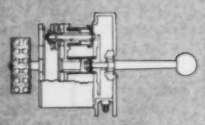
Reduce friction and lost motion.

Eliminate brinelling.

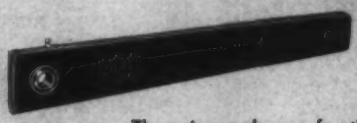
Economical to buy — easy to install.

A few examples of Unibal applications:



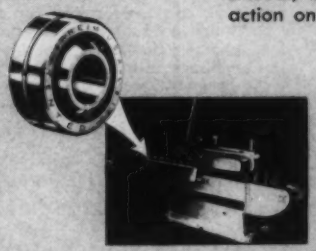


The pivot point for the operating lever which trips the motor switches controlling the searchlight is a Heim Unibal Bearing. This is a Carlisle & Finch electric searchlight controller.



There is no chance for the stud hole to enlarge in this sweepstick. The Heim Unibal Bearing assures smooth, trouble-free pick action on any loom.

The transmission shifter rod on the giant Failing Oil Well Drilling Rig passes through this Heim Unibal to misalign with the changing position of the shaft.



This end of the Helicoid Timer on the Anchor Steriseal Machine is supported by a self-aligning Heim Unibal Bearing.

The Heim catalog shows the complete range of sizes and load ratings. Please write for copy, or for specific engineering data.

THE HEIM COMPANY / Fairfield, Connecticut

only circuit breakers
can be tested!
...and tests prove
Westinghouse AB breakers
protect at the precise rating
you need

breaker protection is *sure* and *accurate*

YOU CAN BE SURE...IF IT'S Westinghouse

J-90232

PRE-TESTED CIRCUIT PROTECTION IS "INSURANCE"

by H. D. Dorfman
Westinghouse Electric Corporation

A most important consideration in selecting a circuit protective device is its ability to protect at the precise rating for which it is designed. Under-rated devices are nearly as bad, though not as hazardous, as over-rated ones. Load testing is the only positive way to be sure a circuit is truly protected.

Obviously, fuses cannot be calibrated and load-tested. An operation-tested fuse is like a tested match, of no further use. Thus, precision protection may not be assured.

Circuit breaker accuracy can be tested by the manufacturer before shipping and retested, if desired, in the field. When tested breakers are provided by a reputable company, you can be sure they will protect at exactly the rated load.

Heat-Treating Important

A number of factors distinguish the properly designed and tested breaker. Life-long maintenance of calibration is assured by several preliminary steps. Heat-treating of bimetal subassemblies relieves any stresses set up during manufacture and insures their permanent "set." Failure to heat-treat can result in later destruction of calibration by load cycles.

Latching surfaces should be ground and polished to eliminate erratic tripping. Latch members also should be heat-treated to prevent wear and distortion. To insure perfect mating of parts, the production and assembly of circuit breakers should take place in a temperature and humidity-controlled area.

Tests Verify Calibration

These tests conducted on all Type F breakers made by my company, for instance, typify the painstaking care necessary to assure the protective quality of such devices.

1. Magnetic elements are adjusted to trip at ten times the thermal rating.

2. After pre-setting of calibrating screw, thermal elements are tested to trip the breaker at a specific overload, within strict limits.

3. Only after the second successful thermal tripping run is the cover assembled on the breaker.

4. Following a 5,000-volt insulation check, the thermal calibration is again test-verified to determine that bimetal calibrations were not altered before or during breaker cover placement.

Such tests assure positive circuit protection at the precise rating for which the circuit breaker is designed.

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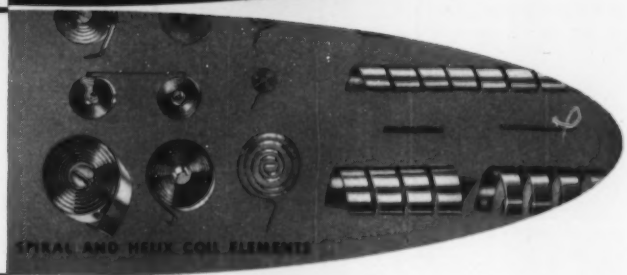
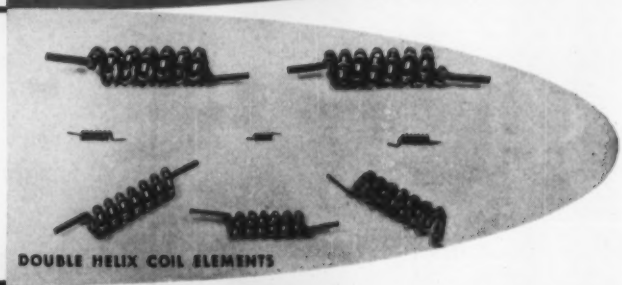
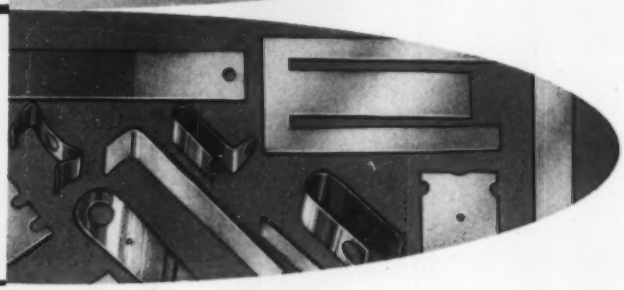


Performance



with Economy



For better control, indication, or compensation of temperature in your products, look to Truflex Thermostat Metal parts. Here's why:

- Every piece, whether in lots of 10 or 10,000, is a duplicate of the original — eliminating rejects and costly adjustments in assembly.
- Truflex Thermostat Metal Parts and Sub-Assemblies are engineered to your specifications, ready for installation.
- Production problems, special equipment, prolonged experimental work, expensive calibrating operations are all eliminated when you use Truflex parts.
- If you prefer to make your own parts, Truflex Thermostat Metals are available in extra long coils or flat strips manufactured to exacting specifications.

You can profit by using General Plate clad metals.

Why not send us a drawing of one of your thermostat metal parts, and let us show you what we can do? No obligation.

METALS & CONTROLS CORPORATION

General Plate Division 2006 Forest Street, Attleboro, Mass.

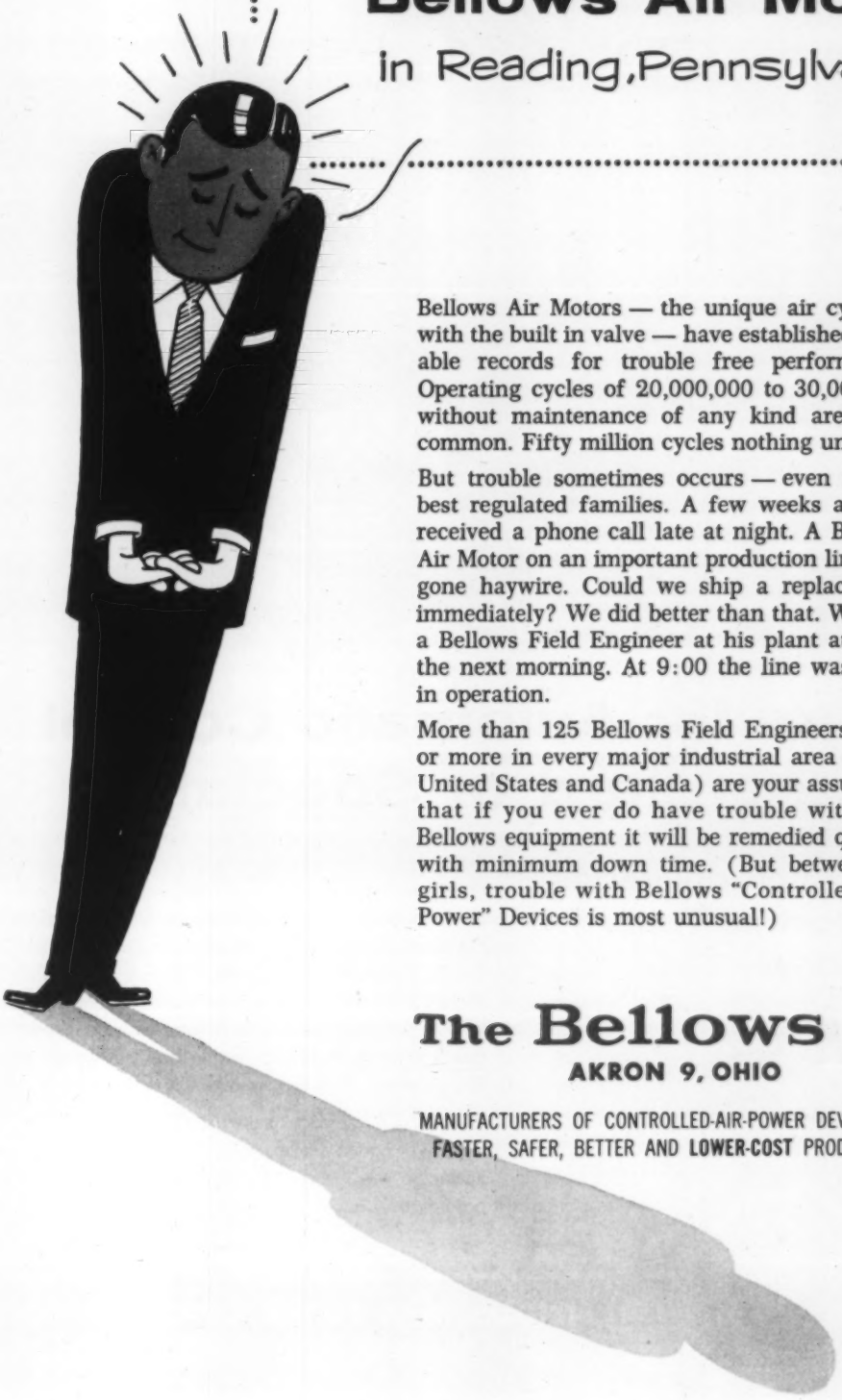
FIELD OFFICES: NEW YORK, CHICAGO, DETROIT, MILWAUKEE, LOS ANGELES

Circle 608 on page 19

We hate to admit it but we had trouble with a

Bellows Air Motor

in Reading, Pennsylvania



Bellows Air Motors — the unique air cylinder with the built in valve — have established enviable records for trouble free performance. Operating cycles of 20,000,000 to 30,000,000 without maintenance of any kind are quite common. Fifty million cycles nothing unusual.

But trouble sometimes occurs — even in the best regulated families. A few weeks ago we received a phone call late at night. A Bellows Air Motor on an important production line had gone haywire. Could we ship a replacement immediately? We did better than that. We had a Bellows Field Engineer at his plant at 8:00 the next morning. At 9:00 the line was back in operation.

More than 125 Bellows Field Engineers (one or more in every major industrial area in the United States and Canada) are your assurance that if you ever do have trouble with any Bellows equipment it will be remedied quickly with minimum down time. (But between us girls, trouble with Bellows "Controlled-Air-Power" Devices is most unusual!)

The Bellows Co.

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MANUFACTURERS OF CONTROLLED-AIR-POWER DEVICES FOR **FASTER**, SAFER, BETTER AND **LOWER-COST** PRODUCTION

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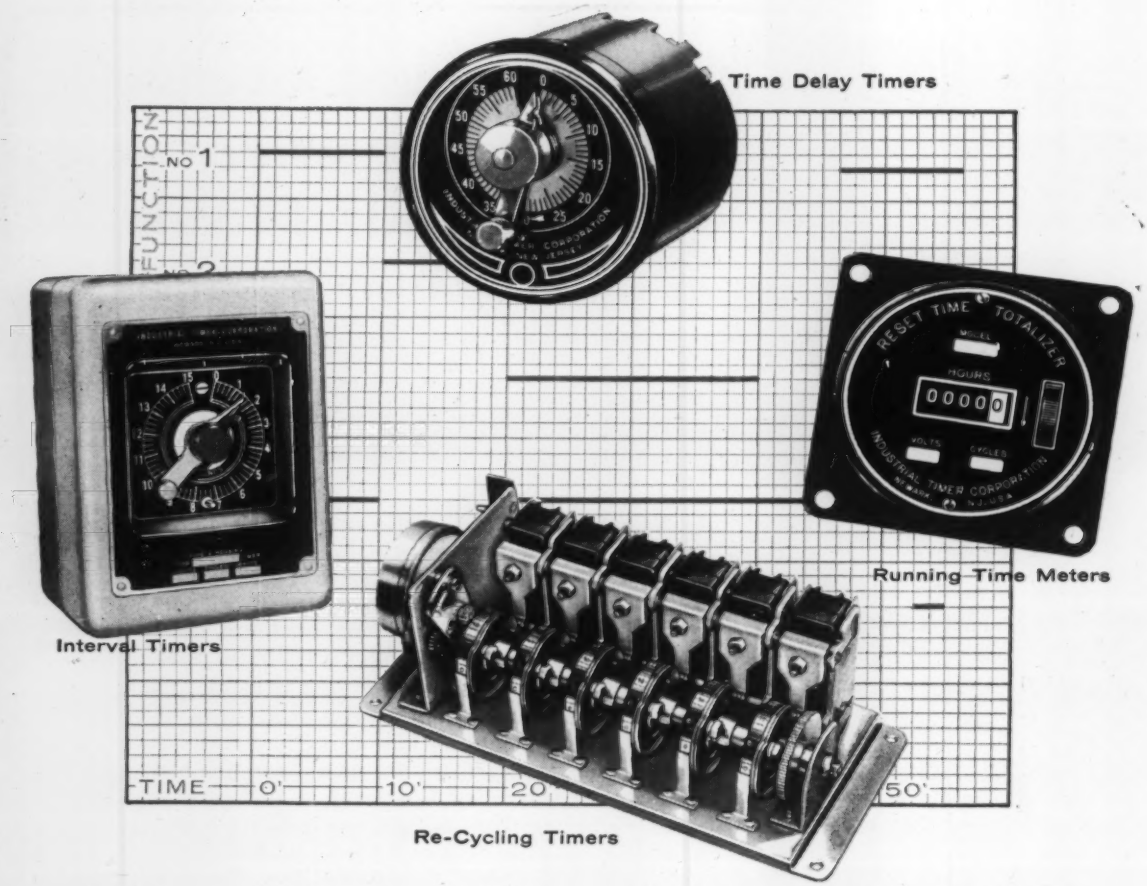


Timers for Automatic Control ...Standard or Special?

You'll get quick deliveries from Industrial Timer

If slow deliveries of timers have been delaying you in your automatic control projects, try us! True, your problem may be different and difficult indeed, for no two automatic control jobs are exactly alike. But our record in helping out in situations like these is excellent. For in this field we have a valuable background, twenty years of timer experience to be exact, that has provided us with the special knowledge required to supply our customers with the right answers.

How do we do it? The answer is in what we believe to be the largest variety of standard and combination timer units anywhere in the industry. To fill the widely varying needs of our customers, we manufacture a complete line of timers in the four broad classifications illustrated above: Time Delay Timers, Re-Cycling Timers, Interval Timers, and Running Time Meters. From these our timer engineers have developed 20 basic types which they have so far combined in over 1000 different ways. Therefore—many jobs that would seem to require a special timer, are in fact, a standard timer with us.

And our large stock assures you of rapid deliveries—even when we have to create a brand new timer for your special needs. So why not send us your specifications. You'll get a prompt reply and you may save yourself much lost motion.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION

1413 McCARTER HIGHWAY, NEWARK 4, N. J.

Circle 610 on page 19

First in the Nation

1. 75-foot continuous treatment strip machine, left, and automatic Spra Bonderite, right, in Parker's new customer service lab.

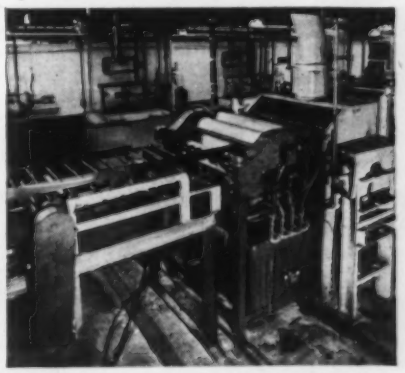
Now, for the first time in the industry, Parker Rust Proof Company brings you a way to test surface treatment of metals on a production line basis, *before* you install surface treatment equipment in your plant.

You can save time, trouble and money by making use of the extensive research facilities of Parker's unique new customer service laboratory. It's a research lab with production line equipment, run like a production line.

This automated lab can treat sample stock by the ton. It is equipped to prepare samples and conduct tests involving all of Parker's varied and outstanding surface treatments of metals.

If you have a metal surface treatment problem, you are cordially invited to make use of this new testing service. Just contact your nearest Parker representative, or write or call Parker Rust Proof Company.

2. Tons of steel in coils await treatment in the strip and sheet treating machine.

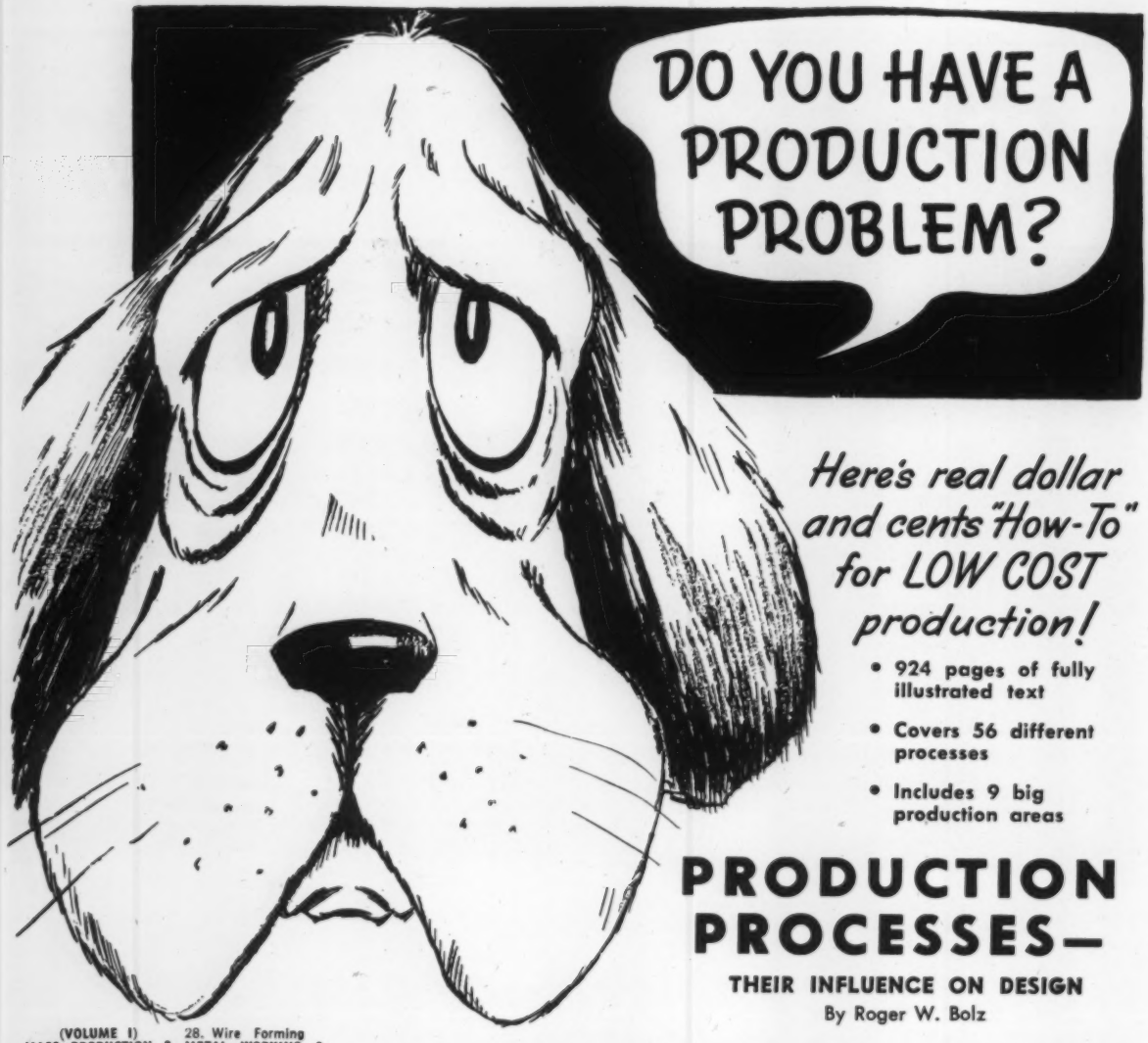


3. Bonderlube is applied over Bonderite treatment for cold forming sample. Roller coating section at end of strip machine is interchangeable.

PARKER
RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1914—leader in the field

Circle 611 on page 19



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THEIR INFLUENCE ON DESIGN

By Roger W. Bolz

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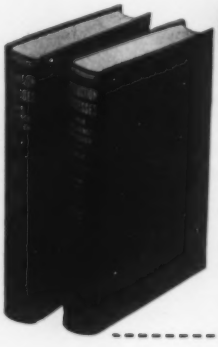

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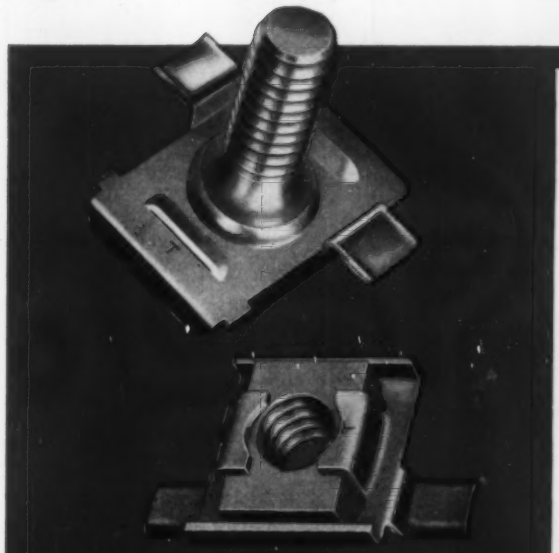

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Circle 613 on page 19

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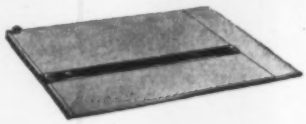
These fine MAYLINE straightedges fit all tables!



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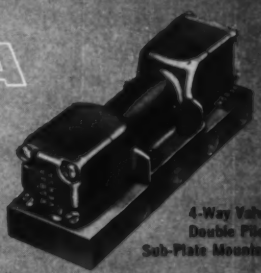
Circle 615 on page 19

FOR SUB-PLATE MOUNTING

VERSA Manifold Mount VALVES



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Available for Immediate Delivery!

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Circle 616 on page 19

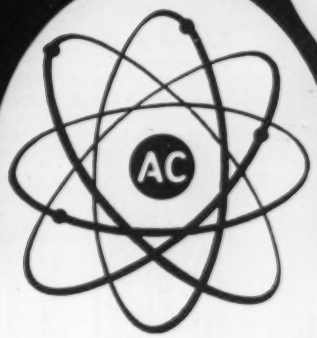
MECHANICAL ENGINEERS

DESIGN

DEVELOPMENT

PRODUCTION

Ever wanted to be a member of a real championship team?? As a member of the Product Development Engineering Department your "team play" will include:



DESIGN You create basic design concepts based on practical means of accomplishment. Your concepts are translated by layout draftsmen to a more communicable form under your guidance. In other words, HOW, WHAT, WHY, WHERE systemized.

DEVELOPMENT You evaluate, refine and improve; using the finest PRODUCT IMPROVEMENT TOOLS. These "TOOLS" include the best TEST and RESEARCH facilities available and you have the added advantage of working alongside the top men in this field.

PRODUCTION You supervise the evolution of a production model based upon engineering prototypes resulting from the Design and Development. Produceability and a high degree of reliability will be your responsibility. Your job will include the maintainability and function of Electro-Mechanical Devices, Precision Gear Trains and Packaged Electronics in the fields of Inertial Guidance, Avionics and Jet Engine Fuel Controls.

Job assignments are accomplished by men operating as a team. Our program is expanding and Challenging Opportunities await qualified men for important positions on our Engineering teams. Why not you??
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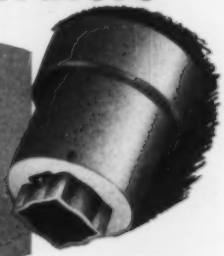
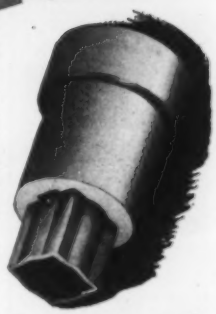
Circle 618 on page 19

High-Impact-Strength High Temperature BRUSH HOLDERS





New PHOENIX "Pemester"

High performance Phoenix "Pemester" Brush Holders and Caps are for motors that get the really rugged duty . . . new "Pemester" material gives high-impact-strength, dimensional stability up to 400°F. and molds to close tolerances in any quantity . . . Available *only* from Phoenix in the complete "Customized-Standard" line of sizes and types—or to your specifications.

Write for full information contained in big, new, easy-to-use Phoenix Catalog 57-L. Your copy free on request.

PHOENIX ELECTRIC MANUFACTURING CO.

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Circle 619 on page 19

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1957

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- Drawing Sets
- Drafting Materials
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ALVIN MECHANICAL LEAD HOLDERS

• Sure-grip mechanism prevents lead from slipping • Push-button, coil spring action quickly adjusts lead to desired length • Perfectly balanced, featherweight barrel of hard rubber, only 1/3 oz. • Jet black finish.

ATTRACTIVE TRADE DISCOUNTS

ALVIN Before you buy . . . See ALVIN CATALOG! Send Today!

ALVIN & COMPANY INC. Windsor, Connecticut

Circle 620 on page 19

NEXT TIME YOU NEED

RELAYS

GET A "QUOTE" FROM

COMAR

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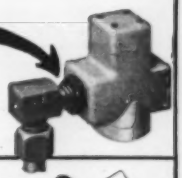
RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

Circle 621 on page 19

TRU-O-SEAL
TEFLON SEAL

STOPS PIPE THREAD LEAKS

PAT. PENDING



Satisfaction Guaranteed Or Money Back TRIAL OFFER

TRU-O-SEAL Fittings are guaranteed to seal pipe thread connections permanently against all oils, practically all known chemicals and gases; to seal under high pressures or vacuum; to withstand —280° to plus 500° F.; to eliminate "overtightening" damage and pipe dope. Available in ⅛" to 2½" pipe thread sizes.

$10.00 Trial Offer No. 1: eight ⅛", ten ¼", eight ⅜", ten ½" pipe thread TRU-O-SEAL Fittings.

$10.00 Trial Offer No. 2: eight ½", ten ¾", four 1" pipe thread TRU-O-SEAL Fittings.

Send order to

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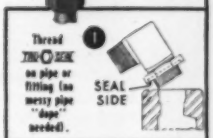
Flick Reedy Corporation
2006 N. Hawthorne Melrose Park, Ill.

"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

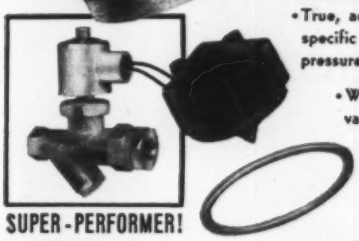
Circle 622 on page 19

TINY PACKAGE FANTASTIC PERFORMANCE

HAYS "MESURFLO" CONTROL

NEW PATENTED WATER FLOW DEVICE

- True, accurate way to obtain specific flow rate regardless of pressure, to 150 psi.
- Wide range of flow rates; variety of pipe sizes
- Low cost
- Request Folder 231



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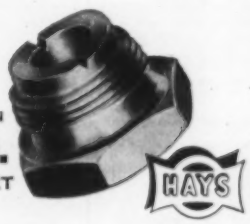

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Circle 623 on page 19

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SILENT-LIGN PILLOW BLOCKS for shaft mounting. Has all Flexible Bearing features.

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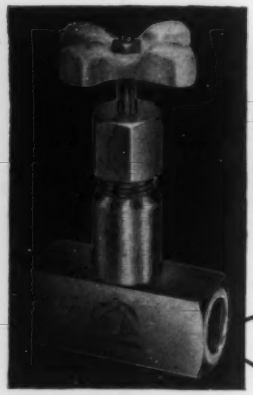
Circle 624 on page 19



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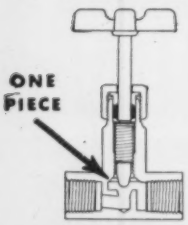

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Circle 625 on page 19

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CUSTOM-BUILT: Indicating meter-relay "heart" and control circuit designed for your application. Dial can read RPM, PERCENT LOAD, FOOT CANDLES, ETC.

VERSATILE: Operates directly from any electrical signal. Adjustable control point. Meter-relays interchangeable. 5 ampere load switch. Optional rating to 40 amperes.

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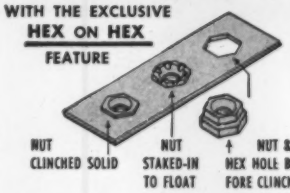
USE GRIPCO CLINCH NUTS

WITH THE EXCLUSIVE HEX ON HEX FEATURE



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Circle 626 on page 19

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SUBSIDIARY OF UNITED-CARR FASTENER CORP.

Circle 627 on page 19

Circle 628 on page 19

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Aluminum . . . Titanium . . . and Wood

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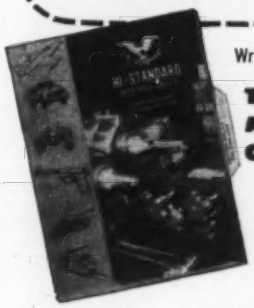

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THE HIGH STANDARD MANUFACTURING CORPORATION
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Pioneers and Makers of Deep-Hole Drills For More Than 30 Years

Circle 629 on page 19

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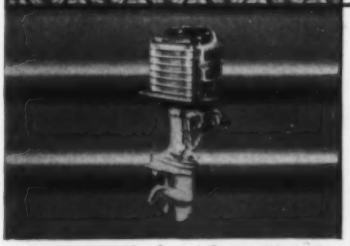
demonstrates its Superiority ON THE WATER

The low weight-high strength ratio of aluminum RIGID-tex Metal (Pattern 6-WL) makes possible a weight of only 45 pounds for this 8 ft. pram.



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Circle 630 on page 19

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PLAIN TYPES

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	ANALYSIS	RECOMMENDED USE
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Circle 631 on page 19

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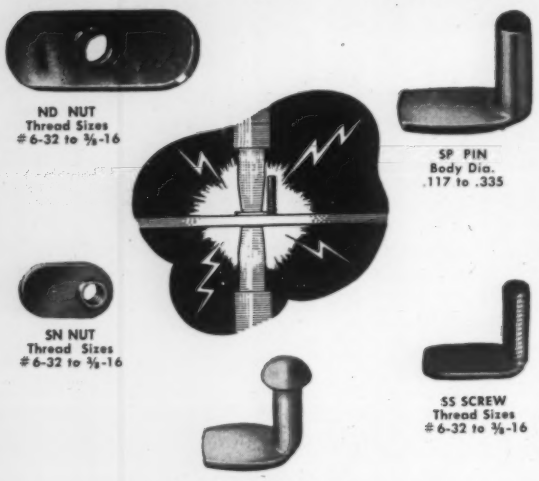

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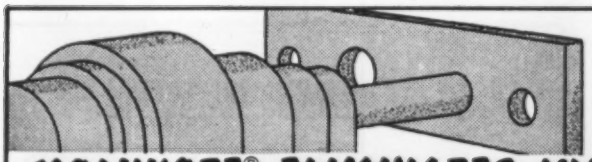

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Circle 634 on page 19

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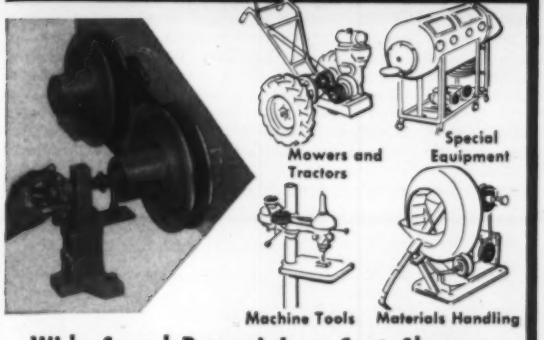

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Circle 635 on page 19

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precise control

20 TURNS moves the stem only 3/8"

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Circle 636 on page 19

Abart SPEED REDUCERS for

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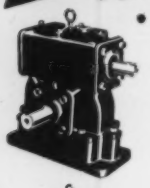

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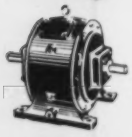

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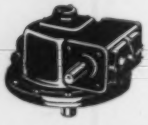

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Circle 637 on page 19

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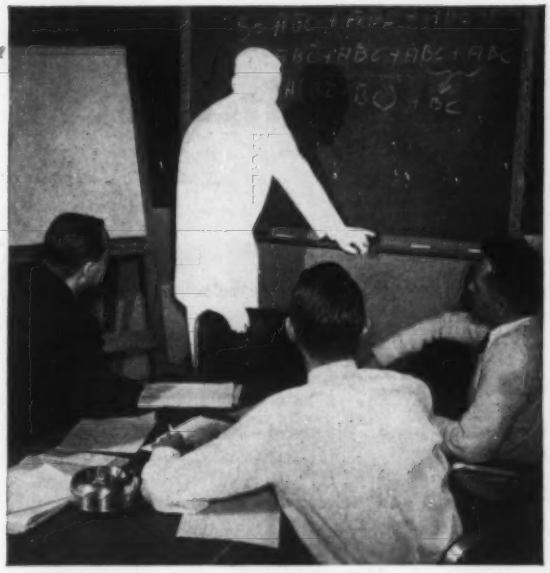
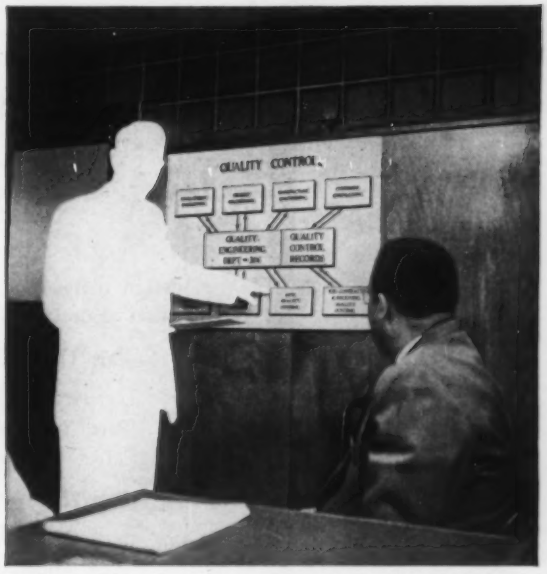


Computer Logical Design Engineer: Before his recent promotion, this man was responsible for determining the broad systems outline of an electronic computer and its interconnection with external equipment. "In this job," he says, "you tailor such characteristics as computer speed, memory, size and arithmetic structure to the requirements of the computer system." He maintained close liaison with mathematical support, circuit designers, packaging and test engineers.



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Subscription in United States, possessions and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyright 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NEP

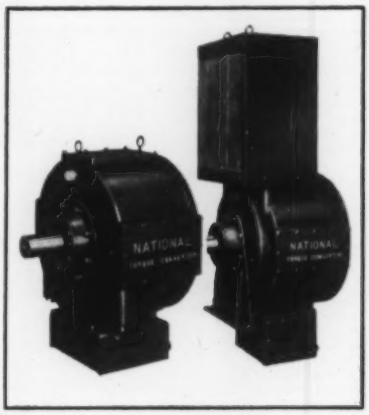
This National Torque Converter, in use on an oil drilling rig, is closely related by design to our new line of torque converters for general industrial use. They range from 100 to 1000 hp.

How National Torque Converters reduce power transmission costs

Power transmission equipment on heavy-duty machinery must take such terrific punishment that the first question experienced operators ask is not "How much does it cost" but "How much does it cost to *maintain?*" And in this figure, they include the cost of any repair or replacement down-time!

Here's an answer from the oil field, where no weakness is tolerated in either men or machines, and even normal service constitutes a "torture test." A user had three National Torque Converters connected to 550-hp diesels serving a rig drilling near Odessa, Texas. After three years and two months of round-the-clock operation with no repairs to the converters, the rig was overhauled. Only replacement needed was one mount and bearing in one converter unit.

What, besides saving money, can a National Torque Converter do for *your* big machinery? Well, it can eliminate engine stalling and overloading, let the driven machine work at full capacity every minute no matter how the load may vary. It can eliminate wrestling matches between operator and controls. It can "up" the daily output of the machine.



National Torque Converters are manufactured with or without integral cooling systems.

If you operate heavy-duty machinery from 100 to 1000 hp, for earthmoving, logging, mining, or similar assignments, our twenty years of fluid transmission experience can probably help you save. Let one of our engineers study and analyze your problem, and tell you how National Torque Converters might serve you. Write: The National Supply Company, Two Gateway Center, Pittsburgh 22, Pennsylvania.

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

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Fastener Facts

DESIGN PRODUCTION & PURCHASING DATA

by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

FASTENING WITH DEEP-DRILLED RIVETS

When to specify:

You specify deep-drilled rivets (sometimes called tubular rivets), when you want low-cost, permanent fasteners for leather, plastics, rubber, wood, canvas and other easily-pierced, compressible materials.

Millions of Thomson Deep-Drilled Rivets are used each year by leading manufacturers of leather goods, luggage, shoe skates, baseball shoes, camera cases, hand bags, golf bags, and other sporting goods. These self-piercing rivets are used to replace or reinforce stitching.

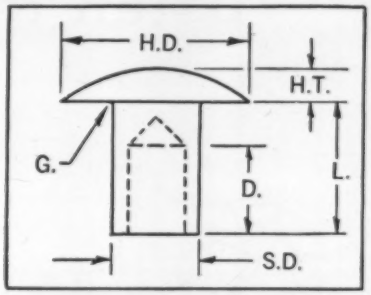
How you benefit:

With Thomson Deep-Drilled Rivets, you can eliminate the cost of pre-punching or pre-drilling holes in materials. Drilled to a depth up to ½" they punch their own holes through the material and compress it within their hollow shanks. Clinched by high-speed automatic rivet-setting machines, which can be operated by unskilled help, they keep assembly time and costs at a minimum.

What dimensions:

Hole Depth (D) of standard deep-drilled rivets always exceeds shank diameter, but never exceeds ½". Exact depth is determined by the compressibility of materials to be fastened and by the clinch requirements of the application. A rule of thumb is to add shank diameter to the thickness of the compressed assembly. The safe rule is to have tests run on actual samples.

Head Diameter (H.D.) ranges between 1.75 and 2.75 times shank diameter for rivets produced by single-blow heading machines. Head diameters up to 3½ times shank diameter are possible . . . at higher cost.



Head Thickness (H.T.) ranges from 0.3 to 0.6 times shank diameter, depending on head shape: oval, flat countersunk, ideal, beveled flat countersunk or cone.

Shank Diameter (S.D.) of standard sizes ranges from .040" to .320".

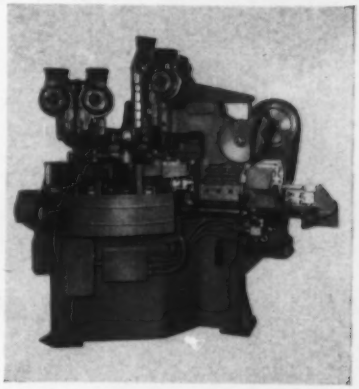
How Clinched:

You have a choice of two clinches with Thomson Deep-Drilled Rivets, depending on the required strength: roll clinch or scored clinch. Roll clinch, produced by correctly-shaped anvils (either solid or spring pilot type), is stronger. Scored clinch is specified when clinch must be turned into the surface of the work.

Thomson Deep-Drilled Rivets are also clinched inside caps which match rivet heads to improve the appearance of the assembly and increase the strength. Washers (burrs) are also used to prevent the clinch from tearing loose by giving a stronger bearing against soft surfaces.

High Speed Setting Machines:

The inherent economy of rivets as fasteners is multiplied by high-speed assembly with automatic rivet-setting machines. Thomson has developed more than 250 styles of machines which can do thousands of fastening jobs . . . with or without adaptations. Multiple rivet-setting heads, special work handling and loading fixtures are optional features that accelerate riveting operations. Thomson selects and custom-tools the proper machine to speed assembly and reduce costs. Available on a sale or lease basis.



Automatic Rivet-Setting Machine

Design and engineering service:

Thomson analyzes your company's fastening problems and makes specific rivet and machine recommendations . . . at little or no cost. When called in early, we can often meet your requirements with standard rivets and machines that eliminate the need for costly special fasteners and tooling. For work in progress, submit sketches, prints or samples for suggestions and quotations.

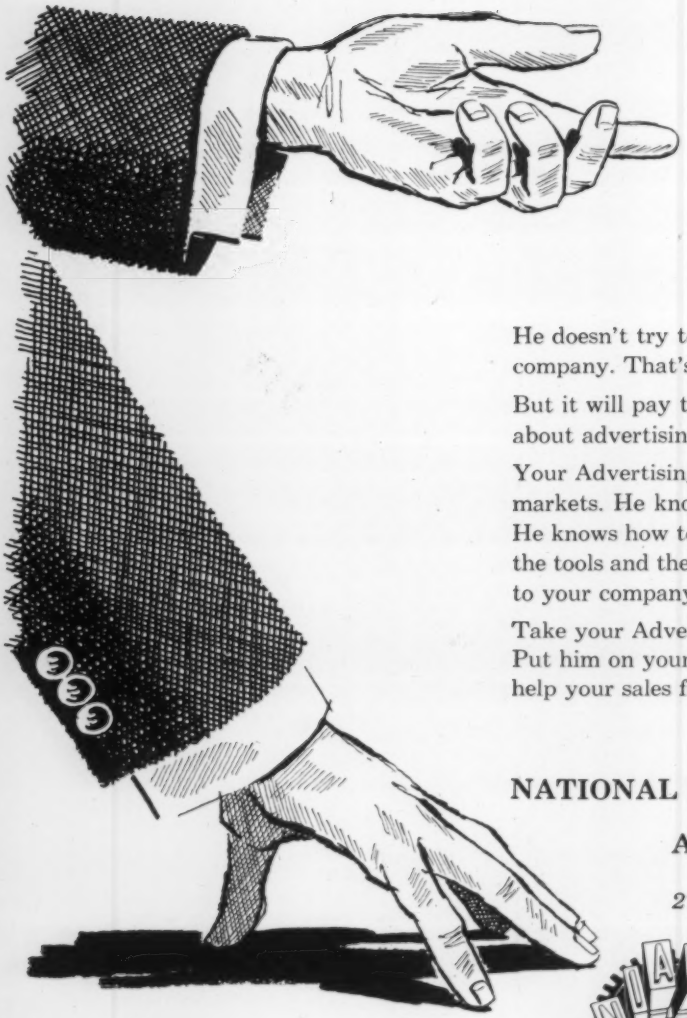
Free "Fasteners Fact File"

(Off the Press Shortly)

Our new manual on all phases of riveting belongs in the hands of everyone who specifies or buys fasteners. It covers rivet types, applications, materials and other factors that determine the selection of the right design, rivet and machine for cutting fastening costs. Reserve your copy today. Write Judson L. Thomson Mfg. Co., Department B, Waltham 54, Mass.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

Does your Board of Directors listen to this man?



He doesn't try to tell your Directors how to run the company. That's their job, and he respects it.

But it will pay them to listen to him when he talks about advertising for your company. That's his job!

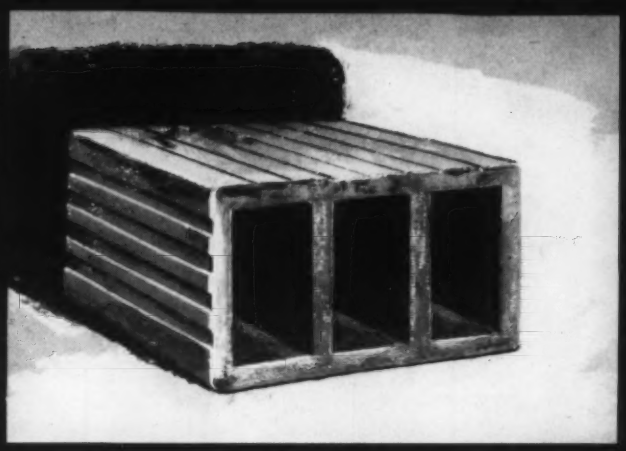
Your Advertising Manager is a man who knows markets. He knows the science of "mechanized selling." He knows how to help turn sales goals into sales. He has the tools and the know-how to make major contributions to your company's progress and profit.

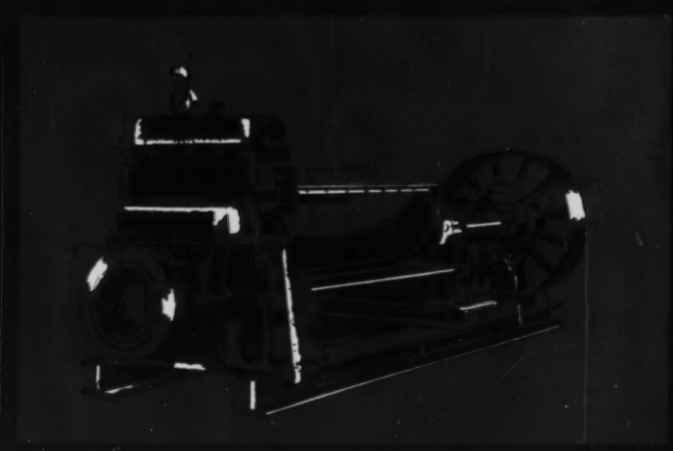
Take your Advertising Manager into your confidence. Put him on your first team. Let him manage. He can help your sales force sell more economically.

NATIONAL INDUSTRIAL ADVERTISERS ASSOCIATION, INC.

271 Madison Avenue, New York 16, N. Y.

An organization of over 4000 members engaged in the advertising and marketing of industrial products, with local chapters in ALBANY, BALTIMORE, BOSTON, BUFFALO, CHICAGO, CLEVELAND, COLUMBUS, DALLAS-FORT WORTH, DENVER, DETROIT, HAMILTON, ONT., HARTFORD, HOUSTON, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, MINNEAPOLIS-ST. PAUL, MONTREAL, QUE., NEWARK, NEW YORK, PHILADELPHIA, PITTSBURGH, PORTLAND, ROCHESTER, ROCKFORD, ST. LOUIS, SAN FRANCISCO, TORONTO, ONT., YOUNGSTOWN.





No Margin for Air–
No Margin for Error

ANOTHER DRIVE REQUIREMENT MEETS ITS MASTER

Yes, it's a fact—unless you remove the air from the clay, you get a no-good tile. And whether air is your problem, or not—error is always a problem. And it's never a mistake to come to Master for the right power drive. In every kind of industry, Master customized package drives give you the utmost in flexibility, compactness and performance.

Here, the primary requirement is power—and the husky, big 200 H.P. Master fills the bill year in and year out. Your requirements might be better met by integrating Master components into a single, efficient, compact unit for the right horsepower, right shaft speed and right mounting features. What are they?

A husky 200 H.P., 440 volt squirrel cage induction Master Motor powers this 14-ton De-Airing Brick and Tile Machine with a capacity of over 8000 bricks per hour. Two parallel shafts carrying pug knives work clay, push it into vacuum chamber with auger cylinders where it is finished and discharged.

Motor Ratings	¼ to 400 H.P. All phases, voltages and frequencies.
Motor Types	Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.
Construction	Open, enclosed, splashproof, fan-cooled, explosion-proof, special purpose.
Speeds	Single-speed, multi-speed, and variable speed.
Installation	Horizontal and vertical, with or without flanges and other features.
Power Drive Features	Electric brakes (2 types)—5 types of gear reducers up to 432 to 1 ratio. Mechanical and electronic variable speed units—Base drives—every type of mounting.

MASTER

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO

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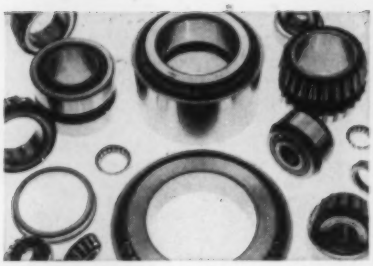
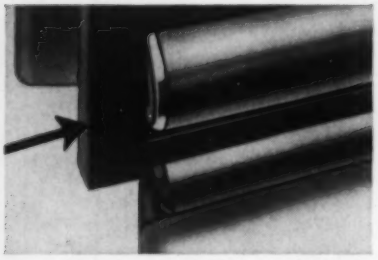
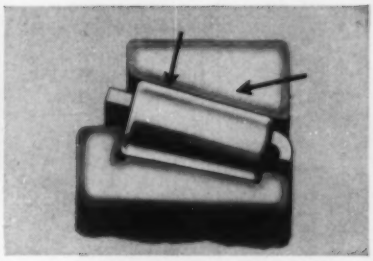
Get all these advantages . . . specify TIMKEN® tapered roller bearings



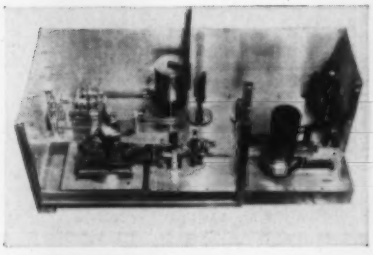
THERE ARE 27 TYPES of Timken® tapered roller bearings. This wide selection means you get the bearing design exactly suited to your job. Whatever your bearing application problem, we can help solve it.



THE SOFT STEEL CAGE used in Timken tapered roller bearings separates the rollers, keeping them spaced evenly. This prevents scuffing of the rollers, adds to the bearing life and gives you more for your money.

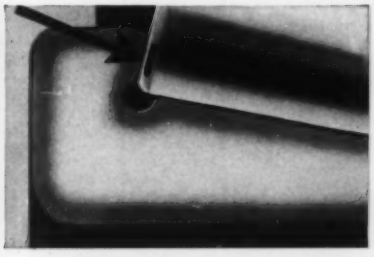


HARD ON THE OUTSIDE, tough on the inside. To take shock loads, give longer life, Timken bearing rollers and races are case-carburized to have a hard, wear-resistant surface over a tough, shock-resistant core.



MICRO-INCH FINISH is standard for Timken bearings. This profilograph checks contours and smoothness of circular surfaces to a millionth of an inch, helps us make Timken bearings truer, quieter, longer-wearing.

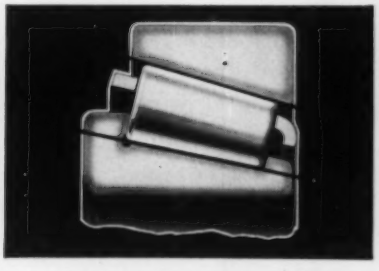
6,525 SIZES, the world's largest selection of tapered roller bearings. From bearings smaller than your finger to 71½" in inside diameter, the Timken Company can supply the size you need for any specific application.



POSITIVE ROLLER ALIGNMENT is assured because the taper in Timken bearings holds ends of rollers snug against the rib. The taper in Timken bearings lets them take radial or thrust loads or any combination.

ACCURATE TO 50 MILLIONTHS of an inch. This Universal Measuring Machine checks gages and machine parts used to make Timken bearings. Our gage laboratory, one of the world's best equipped, helps make Timken tapered roller bearings your No. 1 bearing value.

WE MAKE OUR OWN FINE ALLOY STEEL. No other American bearing maker does. This spectrometer helps control steel quality—in 40 seconds gives the exact chemical analysis of a melt. In a few minutes, results are flashed to the melter. It's another step in rigid quality control.



FULL LINE OF CONTACT between Timken bearings' rollers and races gives them *extra* load-carrying capacity. To get *all* these advantages, specify "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TIMKEN *TAPERED ROLLER BEARINGS ROLL THE LOAD*

TRADE-MARK REG. U. S. PAT. OFF.

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